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contents

editorial

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Dear colleagues and readers of *Científica Dental* magazine,

Included in this 9th year of the special English-language supplement of *Científica Dental*, are the best papers published during 2021 in the categories of Best Scientific Article, Clinical Case and Best First Publication or First-time Author. A total of 6 papers are presented, which are the finalists in the aforementioned categories.

As we always try to do at *Científica Dental*, the subject matter of the articles is current and varied. The first winners are in the area of Oral Surgery and Implantology. The clinical study by Ripollés et al. compares the use of hyaluronic acid gel with chlorhexidine in the postoperative period following third molar exodontia. Peña et al. present a clinical case of a single implant of great aesthetic importance in the anterior sector, and Fernández-Baca et al. carry out a systematic review on the use of particulate dentine in alveolar preservation. Also noteworthy for their interest and scientific rigour, are studies by Grano de Oro et al. and Parziale et al., in the area of endodontics, and Medina et al. on the diagnosis of and factors related to hyposialia in patients with xerostomia. Our readers can have free access to this issue at the following link, cientificadental.es

As always, we would like to thank our authors for the high quality of the papers submitted and for their trust in us to publish them in *Científica Dental*, as well as the editors and reviewers, whose work is essential for the production of each issue of this journal; and finally, of course, our readers, to whom this issue, which includes the most significant papers published during 2021, is especially addressed.

Dra. Cristina Meniz García

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Original article

Pilot clinical study of the efficacy of a hyaluronic acid (1%) and chlorhexidine (0.20%) gel in post-extraction dentistry

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ABSTRACT

Objective: The objective of the present study was to compare the efficacy, in terms of oral healing and post-surgical pain, in a group of patients treated with an oral application of 1% hyaluronic acid (HA) together with 0.20% chlorhexidine (CHX), compared to patients treated with placebo and a third group treated with HA 0.20%, CHX 0.20% + Panthenol.

Method: The study design is an analytical, experimental, randomised, blind, prospective longitudinal study. A sample of 45 patients was randomised and divided into 3 comparison groups of 15, with each group receiving a different composition gel after a dental extraction. The control group received a gel of 0.20% hyaluronic acid and 0.20% chlorhexidine; the placebo group was applied a gel of similar consistency but without the active ingredients; and the experimental group received a gel with 1% hyaluronic acid and 0.20% chlorhexidine. Efficacy variables were measured at 24, 48 and 72 hours and 7 days.

Results: For post-operative pain, we found no statistically significant differences in any of the groups analysed. For healing, the group receiving 1% hyaluronic acid and 0.20% chlorhexidine had the best results from a statistical point of view in the first 24-48 hours compared to the other two groups.

Conclusions: The results obtained seemed to show that topical application of 1% hyaluronic acid together with 0.20% chlorhexidine influences soft tissue healing positively after a tooth extraction; however, it does not seem to have any beneficial effects on post-operative oral pain.

KEYWORDS

Chlorhexidine; Hyaluronic acid; Healing; Dental extraction.

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INTRODUCTION

There are countless pharmacological chemicals used in dentistry for different purposes (e.g. for antiplaque, remineralisng, bleaching and desensitising) used in various forms (e.g. mouthwashes, gels and varnishes). There is scientific evidence about the role they play as adjuvants for various dental treatments applied in dentists to improve therapeutic response. The properties required of these therapeutic oral process adjuvants are specificity, efficiency, substantivity and safety.

Chlorhexidine is the antiplaque agent of choice and probably the most effective against gingivitis and reducing dental biofilm, both inhibiting its synthesis and preventing adhesion to teeth. The most common form it is present in mouthwashes is chlorhexidine digluconate. Based on the aforementioned properties of this compound, its activity in consultations is in a preventive, therapeutic and clinical sphere[1-8].

Hyaluronic acid is a glycosaminoglycan consisting of glucuronic acid and N-acetylglucosamine. Its two most significant properties are as a lubricant and buffer due to the large concentration of water it can retain, conferring it extraordinary elasticity and acting as a defensive barrier in tissues. The clinical qualities of this product are based on improving tissue healing and promoting angiogenesis, and re-epithelialisation based on fibroblastic stimulation, increasing the production of growth factors and biosynthesis of various types of collagen. It is used in dentistry mostly in direct application gels for soft tissue lesions in oral cavities, where studies reveal a reduction in painful symptomatology in the first 24 hours of application[9]. It is worth mentioning that there are few studies of hyaluronic acid applied in oral cavity soft tissues compared with other products used regularly in the mouthwash sector[10-14]. The objective of this study was to evaluate the effects of 1% hyaluronic acid/0.20% chlorhexidine to treat post-surgical pain and promote healing in dental alveoli.

MATERIAL AND METHODS

This is an analytical, experimental, randomised, blind, prospective, longitudinal study carried out according to the Declaration of Helsinki. The San Carlos Clinical Hospital Ethical Clinical Research Committee approved the study with the Code 129RX and all patients were properly informed about it and had to read and sign an informed consent form before participating in the study.

The patient selection was randomised by the data sampling randomisation software, AleatorMetod.xls, into the following study groups:

- Experimental (1% hyaluronic acid and 0.20% chlorhexidine digluconate).
- Placebo.
- Control (0.2% hyaluronic acid, 0.20% chlorhexidine digluconate and panthenol).

All tubes containing the product applied in each group were white and coded with a number unknown to the operator. The relationship between the tube numbers and their content based on the groups was established once the study ended with the data collection notebook. The student was treated by the same operative at all times to prevent bias in the measurements.

Patients were those who attended a clinical consultation at the Centre for Advanced Studies in Implantology and Oral Surgery in Madrid, and were candidates for dental extraction in the positions and conditions required by the study. All data were recorded in a data collection notebook, including possible adverse effects.

The patient recruitment period was from February and August 2018. Patients were included in the study based on the inclusive criteria detailed below:

1.- Volunteers for the research project admitted after the explanation and signing of the written informed consent.

2.- Aged between 18-69 years of either sex.

3.- Teeth extracted: Groups 15-25 and 35¬45 due to decay or periodontal disease without active infection.

4.- People capable of understanding and carrying out the instructions explained by the principal investigator.

5.- Good physical condition, ASA I or II, not taking medication.

6.- Patients collaborating with the programmed appointments in the study.

The treatment to be performed was explained and specific informed consent given, especially regarding local anaesthesia and exodontics. Patients were also informed about the confidentiality of medical data and the procedure. Patients had the option of abandoning the study at any time.

All patients were informed of the inherent risks of dental extraction attached in this study. They were also informed about the application of the chlorhexidine and hyaluronic acid antiseptic products to be applied and the measurements taken.

The tooth extraction was performed in all patients following the inclusion criteria with the minimum surgical trauma by a single operator. To evaluate the degree of healing, the distance was measured in mm with a gauge at the time of extraction. The lingual or palatal vestibular median edge of the soft tissue of the alveolar process of the extracted tooth was taken as a measure and evaluated at baseline, then at intervals of 24h, 48h, 72h and a week. The operator applied the product assigned to the patient in a blind manner in the extraction area after the exodontic procedure, before explaining the need for the patients to apply it themselves at home 3 times a day after meals for 7 days. All patients received written basic post-extraction standards.

To record pain, patients received a data collection sheet with an analogue visual scale (see figure), according to severity: none, mild, moderate or intense. A total of 45 patients were recruited, with each study group containing 15. The sample size was not determined but, similarly to other research studies published in the scientific literature, groups of similar sizes were formed to evaluate the direction of the study target variables, using descriptive statistical parameters; and, as a result, to assess the interest in increasing the sample.

STATISTICAL METHOD

The Shapiro-Wilk goodness-of-fit test for the normal distribution was performed for the quantitative variables of healing and pain. Values that fitted the Gaussian distribution were obtained in both cases throughout the study, as well as for the calculated differences between the different periods; therefore, they are summarised with the mean and standard deviation.

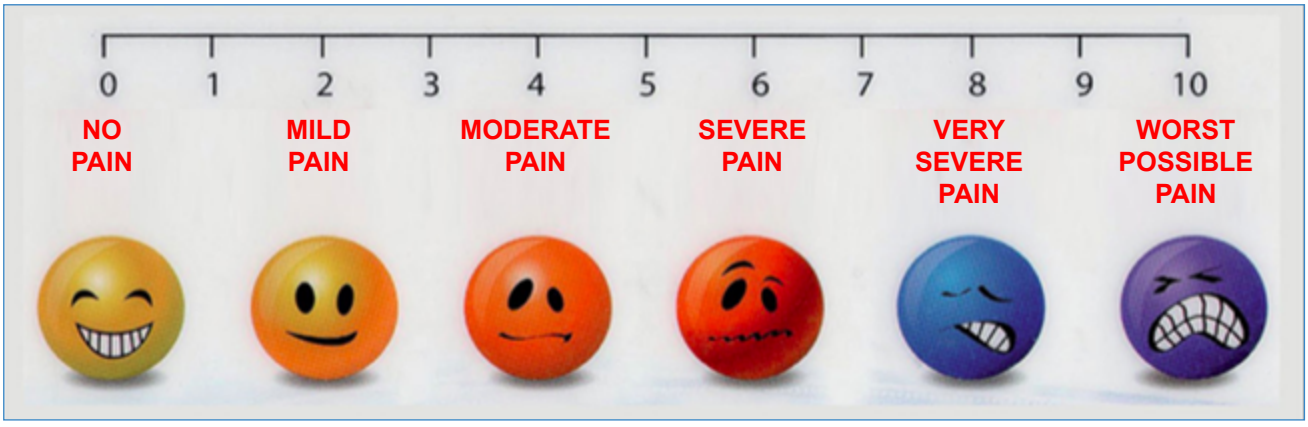

Figure. Analogue pain scale.

The differences in healing and pain between treatments throughout the study were calculated with the one-factor ANOVA test. The differences between groups for 2 x 2 were carried out with the Bonferroni multiple comparison test.

The changes in healing and pain values over time were analysed with general linear model (GLM) repeated measures, as were the differences in the changes between the different treatments. These same analyses were calculated with variables resulting from the difference (delta) for each patient and for the different healing and pain measurement times (A = Initial value-finazl value). Finally, the percentage difference in these values was calculated at all times with respect to initial values or decrease ratio (= (initial-final values) x 100/initial value), by studying the evolution of these variables also as GLM repeated measures, as well as the differences in evolution between the groups.

The difference values (A) and the ratios are summarised with the mean and the standard deviations for each case, calculating the 95% confidence intervals of the means.

A safety level 95% was considered, leading to a statistical significance of $p<0.05$.

All analyses were performed with the SPSS Statistical Package, version 24.0 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.)

RESULTS

Healing analysis by treatment groups (placebo, control and experimental

Table 1 shows the main descriptive data for the patients throughout the study as a total and by treatment group.

Baseline values are somewhat lower in the experimental group (AH 1%, CHX 0.20%), i.e. a little higher in the other two, although these differences were not statistically significant. In subsequent visits, the results were somewhat higher in the placebo group and lower for the other groups, although these differences were only statistically significant at 48 h.

The evolution in the global figure is statistically significant, with p<0.001. The differences in the evolution between the 3 treatment groups had a value of $p=0.380$, which was not statistically significant for any of the 2x2 comparisons between groups.

The values for the decrease ratio of these healing variables are shown in Table 2, with the mean ± standard deviation values, with the mean confidence intervals in brackets. Statistically significant differences were found in the differences between groups when the differences

Table 1. Healing throughout the study and by treatment groups.

	Total N=45	Placebo N=15	CHX 0.20% + AH 1% N=15	CHX 0.20% +AH 0.20% +Pantenol N=15	p
Baseline	5.51±1.96	5.60±1.55	5.27±2.02	5.67±2.35	0.842
24 hours	2.71±1.61	3.20±1.61	2.07±1.39	2.87±1.73	0.143
48 hours	1.11±1.07	1.47±1.06	0.47±0.64	1.40±1.18	0.013
72 hours	0.27±0.62	0.53±0.83	0.00±0.00	0.27±0.59	0.058
1 week	0.04±0.30	0.13±0.52	0.00±0.00	0.00±0.00	0.376

for each patient between baseline and 24, 48 and 72 hours were calculated. No statistically significant differences were found for other comparisons.

Statistical differences between treatment groups, 2 x 2, worth noting are:

- Baseline vs 24 hours in Placebo vs Test (HA 1%, CHX 0.20%; *p*=0.017.
- Baseline vs 48 hours in Placebo vs Test (HA 1%, CHX 0.20%); *p*=0.006.
- Baseline vs 48 hours in Test (HA 1%, CHX 0.20%) vs (HA 0.20%, CHX 0.20%, Panthenol); *p*=0.022.
- Baseline vs 72 hours in placebo vs Test (HA 1%, CHX 0.20%); *p*=0.047.
- 72 hours vs 1 week in Placebo vs Test (HA 1%, CHX 0.20%); *p*=0.033.

Analysis of pain in treatment groups

Table 3 shows the descriptive data of patients by total and by treatment type. The placebo value is higher for all time points, but statistically significant only at 24 hours. The evolution in the total is statistically

Table 2. Comparison of degree of healing measurement ratio differences for all groups at different times.

	Total N=45	Placebo N=15	CHX 0.20% + AH 1% N=15	CHX 0.20% +AH 0.20% +Pantenol N=15	p
Baseline-24 hours	55.0±2.8 (49.3/60.7)	45.9±4.6 (36.0/55.9)	64.8±4.6 (54.8/74.8)	54.2±4.5 (44.7/63.8)	0.021
Baseline-48 hours	82.9±2.3 (78.2/87.6)	76.4±4.3 (67.1/85.6)	93.3±2.3 (88.4/98.3)	78.9±3.9 (70.5/87.3)	0.004
Baseline-72 hours	96.2±1.4 (93.5/99.0)	91.9±3.5 (84.4/99.3)	100	96.9±1.9 (92.9/100.8)	0.049
Baseline-1 week	99.3±0.7 (97.8/100.8)	97.8±2.2 (93.0/100.4)	100	100	0.376
24-48 hours	61.7±4.6 (52.4/71.1)	60.4±6.3 (46.9/73.9)	72.7±8.8 (53.8/91.7)	52.0±8.3 (34.1/69.9)	0.187
24-72 hours	87.3±4.0 (79.2/95.5)	87.7±4.6 (77.8/97.7)	86.6±9.1 (67.1/106.1)	87.6±7.0 (72.6/102.7)	0.993
24 hours-1 week	92.4±3.8 (84.7/100.1)	97.3±2.7 (91.6/103.0)	86.6±9.1 (67.1/106.1)	93.3±6.7 (79.0/107.6)	0.527
48-72 hours	53.5±6.9 (39.7/67.3)	58.3±10.2 (36.3/80.3)	40.0±13.1 (11.9/68.0)	62.2±12.1 (36.2/88.1)	0.377
48 hours-1 week	63.3±7.2 (48.8/77.7)	76.6±10.8 (53.5/99.7)	40.0±13.1 (11.9/6.0)	73.3±11.8 (48.0/98.6)	0.067
72 hours-1 week	18.5±5.8 (6.9/30.1)	35.5±12.4 (9.0/62.0)	0	20.0±10.7 (4.0/167)	0.037

significant with $p<0.001$. The differences in evolution among the 3 treatment groups has a statistically significant value of $p = 0.425$.

As with healing, the percentage decrease is calculated at different time points for pain. These values are shown in Table 4, with the mean ± SD with its confidence intervals in brackets. There are no statistically significant differences, although the values at 24-48h and 24-72h are close to this.

Values close to statistical significance between treatment groups, 2 x 2, worth noting are:

- 24 h vs 48 h in Placebo vs Test (HA 1%, CHX 0.20%); $p=0.068$
- 24 h vs 48 h in Control (HA 0.20%, CHX 0.20%, Panthenol) vs Test (HA 1%, CHX 0.20%); $p=0.068$
- 24 h vs 72 h in Control (HA 0.20%, CHX 0.20%, Panthenol) vs Test (HA 1%, CHX 0.20%); $p=0.064$.

Table 3. Pain by treatment groups.

	Total N=45	Placebo N=15	CHX 0.20% + AH 1% N=15	CHX 0.20% +AH 0.20% +Pantenol N=15	p
24 hours	2.31±1.86	3.27±1.11	1.73±1.5	1.93±2.05	0.045
48 hours	1.67±1.88	2.00±1.85	1.47±1.64	1.53±2.20	0.709
72 hours	0.73±1.51	1.00±2.20	0.67±1.18	0.53±0.92	0.695
1 week	0.22±1.20	0.67±2.06	0	0	0.219

Table 4. Pain value percentage differences for all groups.

	Total N=45	Placebo N=15	CHX 0.20% + AH 1% N=15	CHX 0.20% +AH 0.20% +Pantenol N=15	*p*
24-48 hours	16.7±8.2 (0.18/33.3)	43.7±9.5 (23.3/64.1)	0.zzz0±16.4 (-35.1/35.1)	6.6±14.1 (-23.7/36.8)	0.061
24-72 hours	49.1±7.2 (34.5/63.7)	72.3±12.7 (45.1/99.5)	41.3±11.9 (15.8/66.9)	33.7±11.4 (9.1/58.2)	0.066
24 hours-1 week	66.6±7.3 (51.8/81.3)	79.7±12.0 (53.9/105.5)	66.7±12.6 (39.6/93.7)	53.3±13.3 (24.7/81.9)	0.349
48-72 hours	43.3±6.8 (29.5/57.0)	59.9±12.7 (32.6/87.2)	34.7±11.4 (10.2/59.2)	35.3±10.8 (12.0/58.5)	0.231
48 hours-1 week	60.5±7.4 (45.6/75.4)	68.1±12.6 (41.0/95.2)	60.0±13.1 (31.9/88.1)	53.3±13.3 (24.7/81.9)	0.726
72 hours-1 week	27.4±6.6 (14.2/40.6)	15.6±8.5 (-2.7/33.8)	33.3±12.6 (6.3/60.4)	33.3±12.6 (6.3/60.4)	0.452

DISCUSSION

Topical medication in the treatment of various oral processes is easy to apply. A notable aspect of this study is that the application of a gel (experimental, control or placebo) is that it seems to improve the perception of pain across the board. This is confirmed by Nolan and Lee[14,15]. Consulting the bibliography and confirmed by our study, the absence of side effects during the prescribed application period promotes continuation of the treatment[14-16]. The degree of healing results for the test composition (1% HA) were more favourable than the placebo or control (0.20% HA) groups. No confirmation of these data could be found in the literature as there are no similar studies applying the product on post-extraction alveoli, as it is mostly applied to ulcerated lesions of the oral mucosa. The physical barrier achieved after application of products in gel format probably makes it difficult for infections to appear, as authors such as Saxen[17] and Porter[18]. found. Also, the properties of hyaluronic acid, such as water absorption and subsequent hydration, and structure, in the sense of being the main composition of the extracellular matrix[14-17] seem to indicate a 1% concentration of high molecular weight hyaluronic acid (experimental group) may be more beneficial in terms of healing. Our study applied the products 3 times a day for 7 days, and studies consulted[17-19] show that the dosage in relation to product application may be fundamental, since these authors found a decrease in the benefits of hyaluronic acid when the application changed from continuous to 3 times a day.

Based on the results obtained, applying a 1% hyaluronic acid and chlorhexidine digluconate gel has a beneficial effect for healing within the first 24-48 h of application, compared to the other groups.

We found a certain improvement in the perception of pain by the patient in observations made during the first 24 h. A number of results approached statistical significance for healing of the post-extraction alveolus; therefore, we should contemplate increasing the sample size as well as the dosing frequency, so that a clearer result could be obtained in future studies in terms of statistical power.

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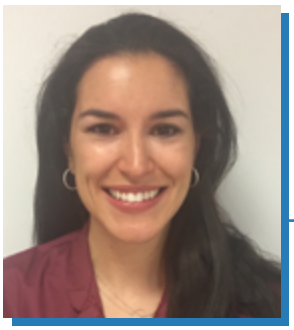

Original Article

Pilot study on the diagnosis of and factors related to hyposialia in patients with xerostomia at a university clinic

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ABSTRACT

Xerostomia is a subjective sensation of dry mouth that may or may not be accompanied by a decrease in the amount of saliva. Hyposialia is a reduction in salivary flow, as measured by sialometry. The aims of the study were to establish the total percentage of patients with actual reduced saliva flow (hyposialia) in a group of patients with perceived reduced saliva flow (xerostomia) and analyse the differences between patients with xerostomia associated with hyposalia and patients with subjective xerostomia.

28 patients with xerostomia were part of the study between November and March 2020-2021 at the Polyclinic of the European University of Madrid. A comprehensive medical history was prepared, 3 questionnaires were completed (Xerostomia Inventory, Perceived Stress Scale and OHIP- 14) and unstimulated sialometry was performed for 5 minutes. Data analysis was performed with the Stata IC v 14 statistics program.

82% of the total patients who reported dry mouth were women, with a mean age of 59.14 years. Less than half of the patients (46%) had hyposialia as evidenced by sialometry. There were more patients with dental prostheses in the group suffering from hyposialia compared to the group with normal salivary flow. Both groups showed a similar number of xerostomising disorders and drugs. There were no significant differences between either group regarding the completed questionnaires.

KEYWORDS

Xerostomia; Hyposalivation; Dry mouth; Xerostomia Inventory; Perceived Stress Scale; OHIP-14.

INTRODUCTION

Xerostomia is the subjective sensation of a dry mouth; whereas hyposalivation is an objectively measured lower volume of saliva produced, according to accepted, standardised values. These two conditions are often confused and misused; they may complementary to each other, but not always. This pathology affects speech, chewing, swallowing and general status. It is also uncomfortable for wearers of prostheses; increases the incidence of tooth decay and periodontal disease; changes the taste of food; leads to halitosis and other symptoms that greatly affect the quality of a patient's life[1]. The literature establishes the prevalence of xerostomia at around 20% of the population, although studies that place it in a range of 10-46% have been published[2]. Among such patients, 30% are women and there is a higher percentage of those with advanced age[2]. A study conducted in an Australian elderly population found 1 in 5 had xerostomia or hyposalivation, with 1 in 6 having both pathologies: 5.6% of the total sample[3].

Given the known aetiology of xerostomia and hyposalivation, there are many studies that focus on the high percentage of the elderly with this pathology due to their polymedicated status, as this is a risk factor for the change in the composition of saliva, leaving aside any general problems of ageing[4]. Among the 14 first-level medication groups of the Anatomical Therapeutic Chemical (ATC) classification system, 9 were reported as xerostomising medications. The most common are anticholinergics, antidepressants, antihistamines, anti-Parkinsonians, anti-hypertensive and sedative agents such as benzodiazepines. All of them are very common drugs in the clinical histories of people of all ages, not just the elderly[5].

Many common diseases have xerostomia among their symptoms, such as diabetes or depression, with this symptom getting worse with increasing prescribed medication, as is the case with Sjogren's syndrome and uncontrolled Parkinson's[6-8]. Even certain treatments, such as head and neck radiation, have this type of side effect in most patients who receive it[9,10].

Stress is a risk factor for xerostomia; it is evaluated with questionnaires and is considered related to it[11]. Smoking also plays a crucial role in this pathology, where it thickens the texture of saliva instead of reducing its volume. The effects of smoking are dependent on the amount consumed[12].

As these two pathologies are different, they have to be diagnosed differently. Xerostomia is a subjective disorder, and is evaluated by a questionnaire, of which here are several in the literature. Predominantly used is the xerostomia inventory, which contains 11 questions and gives a maximum score of 55. It is written in the first person: e.g. "I drink liquids to swallow the food", "My eyes are so dry"[13]. Another simple diagnostic method to evaluate clinical signs is the Clinical Oral Dryness Score (CODS). This evaluates several parameters in a scoring scale of 10; among them are if the dental mirror adheres to the tongue, if there is saliva on the floor of the mouth and if there is a loss of papillae in the tongue[14]. However, to test for hyposalivation, an objective salivary flow measurement, sialometry, is required by. This is a simple test in which the patient expectorates into a container for an average of 5 minutes. This can be unstimulated sialometry or stimulated, using a sugar-free lemon sweet or chewing gum, for example[15]. Normal values for unstimulated sialometry are greater than or equal to 0.1 mL/min, and 0.7mL/min for stimulated[16,17].

Currently, there are few effective treatments available. Initially, a change of habits; stress control; stopping or reducing smoking; reducing the dose of medication or replacing it with another less xerostomising; proper hydration; and eating acidic sweets or chewing gum to stimulate the glands[18]. Another more palliative treatment option is to use topical sialagogues, such as 1% malic acid, which has been shown to significantly increase saliva volume[19]. Systemic sialagogues, such as pilocarpine and cevimeline, parasympathomimetic and muscarinic agonists, have proven effective in the relief of hyposialia even in extreme cases such as patients receiving head and neck radiation. The disadvantages they have are that the stimulation duration is an average of two hours, and numerous side effects can appear[20].

Given the confusion that exists between xerostomy and hyposalivation, and considering that they are not always linked and are managed differently in the clinic, the objectives of this study were to determine the proportion of xerostomic patients actually with hyposialia; the frequency of the disease in the different age groups and their distribution by sex. Their association with habits, stress levels, presence of xerostomising disorders and medications was also assessed.

MATERIAL AND METHODS

The protocol for this observational, prospective and cross-sectional study was approved by the European University of Madrid Ethics Committee (Code CIPI/20/123).

All patients of legal age who attended the University Polyclinic of the European University of Madrid between November 2020 and March 2021 who answered in the affirmative to the question "Does your mouth feel dry?" were included. They were provided with a detailed verbal and written explanation of the study, before signing an informed consent to participation in it.

Firstly, an exhaustive medical history investigation was carried out. Then, 3 questionnaires were filled in: the Xerostomia Inventory, Perceived Stress Scale and OHIP-14.

Finally, unstimulated sialometry over 5 minutes was performed.

All patients were treated by the same investigator between 8 am and 1 pm in the Polyclinic of the European University.

The following variables were recorded for each patient: age, sex, consumption of alcohol, tobacco and other drugs, systemic diseases, habitual medication, dental prostheses held.

In the statistical analysis, absolute and relative frequencies were used to express the qualitative variables. As for the quantitative variables, the standard deviation and deviation were calculated in those that followed a normal or median distribution, and the interquartile range for those who did not. The proportion of patients with both xerostomy and hyposialia and respective 95% confidence intervals were recorded.

A chi square (or Fisher exact test) was performed to compare the qualitative variables of sociodemographic features, habits, comorbidity, usual medication, oral health status, quality of life and the perceived stress of patients, with or without hyposialia. A Student t-test (or Mann-Whitney U test), was performed for quantitative variables for independent samples. Statistical significance was considered a *p*-value of less than 5%. The Stata IC V.14 statistical package was used for data analysis.

RESULTS

Included in the trial were 28 participants with a subjective sensation of dry mouth (xerostomia), of whom 23 were women (82.14%) and 5 men. The mean age was 59.14 years (SD = 14.29), with the youngest being 27 and the oldest 79.

Almost half (13, 46.43%) of the 28 patients had hyposialia, measured via unstimulated sialometry, while 15 had symptomatic xerostomia without hyposialia. The median [Q1, Q3] unstimulated volume was significantly lower in the patients with hyposialia (objective xerostomia) than those with xerostomia without hyposialia (0.01 [0-0.04] vs. 0.22 [0.2- 0.4], mL/min respectively; p <0.001).

Table 1 summarises the sociodemographic and clinical features and habits of the patients while Table 2 compares patients with and without hyposialia. Patients with hyposialia were significantly older (64 ± 9.7 years vs 54.1 ± 15.9 years; respectively, p = 0.044). The number of xerostomising disorders was similar in both groups, with depression being the most frequent in all patients

(Table 3). Selective serotonin reuptake inhibitor (SSRIs) antidepressants were the most common medication with a reported dry mouth side effect.

Measured habits were not significantly different between patients with and without hyposialia. No patient drank alcohol continuously or repeatedly, many occasionally or sporadically in company and some not atall. No patient reported consuming illegal drugs. Only 8 of the patients smoked, represent similarly across both groups. There was also no significant difference between patients with and without hyposialia regarding the amount of fluids drank per day, as well as in the oral hygiene habit of daily teeth brushing.

Finally, a greater proportion of patients in the hyposialia group had prostheses (61.5% vs. 13.3%, respectively; *p* = 0.016) as well as having fewer remaining teeth.

Table 1. Sample features.

Variables	
Age	59,14
Women	82,14%
Xerostomía	100%
Hiposialia	46,43%
Xerostomising medication	64,29%
Xerostomising disorders	32,14%
Removable prosthesis	35,71%

Table 3. Xerostomising disorders.

Disorder	Patients
Biliary cirrhosis	1
Rheumatoid arthritis	2
Head and neck radiation	1
Diabetes type 2	3
Depression	5
Burning mouth syndrome	2

DISCUSSION

In this study, all patients responded to the question: Do you feel your mouth is dry? If they answered 'yes', this subjective sensation was enough for direct inclusion as a xerostomia patient[1]. Of the 28 patients included in the study, 82% were women, who were more represented in the literature for xerostomia[3,11]. In a study conducted on 3,313 Swedish people, the percentage of non-medicated female subjects with xerostomia was 18.8% compared to 14.6% of men. Similarly, the percentage of medicated female subjects with xerostomia was 32.5% compared to 28.4% of men who had the subjective sensation of a dry mouth[21]. This pathology is related to menopausal women on many occasions. The salivary glands contain sex hormone receptors, with the level of oestrogen being capable of varying the secretion and composition of saliva[22]. There are many studies that have focused on this without reaching very conclusive results: Minicucci et al.[23] studied the volume of saliva

Table 2. Comparison betwenn patients with and without hyposialia.

	With hyposialia	Without hiposialia	*p*
Women	11	12	0.333
Age	64.92	54.,13	0.044
Unstimulated volumen (mL/min)	13 (0.03 ml/min)	15 (0.35 ml/min)	< 0.001
Patients with xerostomising disorders	4	5	1.000
Patients with xerostomising medication	13	15	0.124
Patients with prosthesis	8	2	0.016

in a group of women of menopausal age and compared them with a control group of women of childbearing age. There was a significant difference only in the volume of saliva in stimulated sialometry, not at rest. Eliasson et al.[24] showed an increase in the volume produced by the minor salivary glands after a year of treatment with a weak oestrogen (oestriol) in women with more than 5 years of amenorrhea, improving the sensation of dry mouth. However, they showed a statistically significant increase only in stimulated saliva, not at rest.

The average age in this study was 59.14 years old, and older in the hyposialia group. In the aforementioned study, patients older than 60 years showed an exponentially increasing percentage in relation to age[21]. This increase in xerostomia with age has been reported in numerous publications[3,4,11]. The dilemma is to determine whether this relationship of age with xerostomia has its oetiological origin in age per se or in the increased number of drugs and disease associated with age. Nederfors et al.[21] reported a low correlation between dry mouth symptoms in non-medicated patients, thus reinforcing the xerostomia hypothesis as a secondary effect of medications or polymedication and not of age per se. However, Yehl et al.[25] demonstrated a decrease in the total volume of saliva at rest in a cross -sectional study of 1006 patients, with the secreted stimulated by the parotid, and unstimulated and stimulated from the submandibular and sublingual, according to the age of the study group. 46% of the patients in the study who reported having a subjective sensation of a dry mouth had a sialometric volume of less than 0.1mL/min, and were thus hyposialic. This leads to the conclusion that the perception of dry mouth in a higher percentage of patients with xerostomia was subjective. This percentage is greater than that reported by Thomson et al.[3] of 22.1% hyposialia, 20.5% xerostomia and 5.6% subjects who met both conditions. Notably, the patients with hyposialia (or "objective xerostomia") had more removable prostheses, of whichever number or type, than patients with just xerostomia. The effect of xerostomia has been seen in the use of removable prostheses, and not of dentures, in the increase in the sensation of dry mouth [26]. However, Gabay et al.[27] defended saliva production stimulation through the use of a complete prosthesis, which increased the saliva volume by more than double a year after wearing them. Years later, Wolff et al.[28] did not reach the same conclusion: they found the volume of saliva secreted from inserting the removable prosthesis increased after 2 days but, after 3 months, the volume was the same as in the first measurement. In this study, it was found that those patients with fewer remaining teeth were had hyposialia, which is directly related to the use of dental prostheses.

Before the sialometry, the 28 subjects in this study filled in 3 questionnaires: Xerostomia Inventory, OHIP-14 and Perceived Stress Scale; the latter was to determine the patient's stress levels in the last month. The average score for the latter was 25.7 out of 56, with no significant difference seen between the groups. However, the literature has several studies reporting the relationship of stress and xerostomia[11,29]. Also, depression as stress is also a significant risk factor for xerostomia. The most common xerostomising disorder among the study patients was depression, with antidepressants in the xerostomising drug group. There were no differences in the consumption of xerostomising medication, and no increase in the pathology with the number of drugs; this was confirmed in these studies[21,30,31]. In a study carried out on a geriatric population, 44% of the medication prescribed to patients had hyposialia as a side effect, presenting with a greater number of drugs taken by women[30]. In the aforementioned Nederfors et al. study[21], 32.1% of medicated patients had xerostomia, compared to 16.9% for the non -medicated group. Also, a linear relationship was found for the association between the sensation of a dry mouth and the total number of drugs consumed daily. The drugs that induce dysfunction of the salivary glands act directly on the central and peripheral nervous system, many of them dose-dependent, thus increasing severity[31]. Drugs are a clear significant risk factor for xerostomia, which increases with their number and dosage. We must assume that we have not obtained conclusive data in this field due to the small sample number.

There were no significant differences between the groups for the Xerostomia inventory results, with an affirmative average of 31.89. Taking into account that all participants were selected because they felt they had a dry mouth, inventory xerostomia can be assumed to be a good diagnostic tool. It uses simple vocabulary, with short and direct phrases; is easy to for patients to understand and respond to. However, the same could not be said for the Perceived Stress Scale. Given the advanced age and perhaps socioeconomic level of patients who come to university clinics for treatment, understanding the questions was difficult. All were very extensive, repetitive and complex when changing affirmation of the question to a denial. In general, after the initial questions, they were observed to lose interest and answered randomly. A simpler questionnaire for this purpose would be useful in the future.

There are many studies In the literature that use Xerostomia Inventory with very positive results; having been translated into numerous languages[13,30].

OHIP-14 was similar, it being observed that most patients did not see their quality of life-threatened by the state of their oral health; there were no significant differences between the two groups. Marjolein et al.[32] used these three questionnaires in their study of 114 patients. They found stress levels were directly associated with the OHIP-14 results, but with no statistically significant association being found between stress and saliva volume. This confirms the above observation, with the need to increase our study sample size to obtain conclusive data.

Given the SARS-COV2 pandemic, there were few patients able to participate in the study. Due to the fear of infection at a university clinic, patients were treated in boxes in large rooms, with a false feeling of insecurity. Also, dentistry is a practice where the patient cannot use a mask, which contributed to that perception of danger. Also, this serious crisis caused significant professional and economic instability, giving rise to a notable decrease in the number of patients, making our study one with a non-representative sample.

Another constraint on the number of participants was the time restriction for the study. The sialometry had to be done in the morning, in accordance with the circadian rhythm. Salivary glands function according to a genetic clock which varies with the time of day[32,33]. This further limited the testing time and ruled out all those patients who had to work in the morning.

Suggestions for future projects related to this or to its expansion would be a multicentre study with several investigators collecting data and thus increasing the sample size. The method would still be the same, but we suggest looking for a simpler alternative to the *Perceived Stress Scale* for understanding and execution of the questionnaire.

CONCLUSIONS

At the end of the study, more than half of the sample proved to have xerostomia which is the subjective feeling of a dry mouth, not confirmed by saliva testing, as is hyposialia. After studying the data collected, It was observed that those patients suffering from xerostomia were mostly elderly women. The group of hyposialic patients was notable for the proportion of people with dental prostheses. There was no significant differences between these 2 groups for xerostomising conditions or medication. Similarly, no significant differences were found between the groups in stress levels and the quality of life, as measured by the OHIP-14 and *Perceived Stress Scale* questionnaires.

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Clinical case

The challenge of the surgical approach in the rehabilitation of an anterior sector unitary implant in a case of high aesthetic requirements; case report

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ABSTRACT

Objective: Provide a detailed description of the current evidence-based clinical approach to a post-extraction implant with immediate loading and provisionalisation.

Clinical case: A 32-year-old female patient who attended for a possible root fracture of the upper left central incisor (ULCI), accompanied by a periodontal abscess at the bottom of the vestibule of the same tooth. A clinical and radiological examination established that the prognosis of the ULCI was unfavourable for conservative treatment. After evaluating the clinical features of the case, the treatment plan to extract the ULCI followed immediately by an osseointegrated implant (OII) and loading of a provisional prosthesis on the implant.

Conclusions: Rehabilitation on implants in situations of tooth loss in the aesthetic anterior sector, especially in young patients, requires a multidisciplinary treatment plan to extract the tooth and insert an OII in the correct 3-dimensional position. Various aspects need to be taken into account for this, particularly the residual remaining bone, the position of the gingival margin and preservation and conditioning of the peri-implant hard and soft tissues by means of grafts and proper handling of provisional prosthesis, until an ideal emergence profile and gingival contour is achieved before the final crown.

KEYWORDS

Post-extraction implant; Immediate loading; Immediate provisionalisation.

INTRODUCTION

Oral biology has become more important in the 21st century, since it is necessary to highlight the processes related to bone and soft tissue biology, the loss of a tooth and the future of tissues after their replacement with a dental implant.

The physiological processes that take place after the extraction of a tooth are drastic, as they entail a series of modifications in the soft and hard tissues of the alveolar complex. Mainly, the microvascularisation of the architecture that surrounds the tooth suffers damage and atrophy that culminates in a decrease in the vascular supply provided by the periodontal ligament[1-4]. This results in a series of resorption processes discussed in this description of a clinical case.

Advances in oral implantology have brought with it new surface treatments for osseointegrated implants (OII), as well as different macroscopic designs and materials. This has been associated with greater primary stability of the OII and a better prognosis. The current trend in the field of implantology has been an evolution from conventional loading of the OII to immediate loading, due to the greater functional and aesthetic demands of society and patients[5]

The benefits of immediate loading include a marked reduction in surgical interventions, less temporary dilation of the treatment and even better psychological and social wellbeing for the patient. In cases with a significant aesthetic requirement, immediate loading or provisionalisation, and post-extraction placement of the OII minimise alterations due to tooth loss and maintain the emergence profile, soft tissue contour and gingival papillae[5-7].

Different protocols have also been established for the management of the anterosuperior aesthetic sector, in addition to performing the immediate implant and provisional crown, including placing material between the OII and the buccal cortical to minimise possible collapse and the management of peri-implant soft tissue[8-11].

The objective of this article is to provide a detailed, evidence-based description of the clinical approach to a post-extraction implant with immediate loading and provisionalisation.

CLINICAL CASE

We present the case of a 32-year-old female patient referred by her dentist to the Master's of Oral Surgery and Implantology at Rey Juan Carlos University for a possible root fracture of the upper left central incisor (ULCI), accompanied by a periodontal abscess at the bottom of the vestibule region of the tooth.

The patient reported no allergies or drug use for the treatment of diseases and had no -surgical history. She was an ASA class I patient with no smoking or alcohol habits reported.

Examination and diagnosis

The patient's symptoms were pain in the anterosuperior area after chewing that disappeared after the use of non-steroidal anti-inflammatory analgesic drugs.

At the intraoral level, a mid-smile line and fine gingival biotype was observed, accompanied by gingival recessions at the level of the upper right central incisor (URCI), as well as in the first, third and fifth sextant teeth. There was slight crowding in the lower anterior region and evidence of multiple dental treatments, such as root canals and osseointegrated implants (OII).

Erythematous mucosa was observed In the ULCI region, accompanied by inflammation of the apical region of the tooth at the level of the attached gingiva, suspected to be due to a periapical abscess following infection of the tooth (Figure 1). The ULCI had great mobility due to a radicular fracture not observed on clinical examination.

A radiological examination was carried out that included a periapical radiograph and a CBCT to appreciate the distribution of the ULCI fracture better (Figure 2).

The radiographic examination confirmed an oblique fracture that included the region of the middle third of the root and extended in a coronal-palatal direction towards the coronal region. Likewise, the presence of normal root canal treatment and the absence of a vestibular plate in the region of the two coronal thirds of the ULCI root was observed.

Prognosis

After carrying out a clinical and radiological examination, it was established that the prognosis was unfavourable for conservative treatment of the ULCI. After evaluating the clinical features, a treatment plan was established based on extracting the ULCI with immediate placement of a post-extraction OII and loading with a provisional prosthesis.

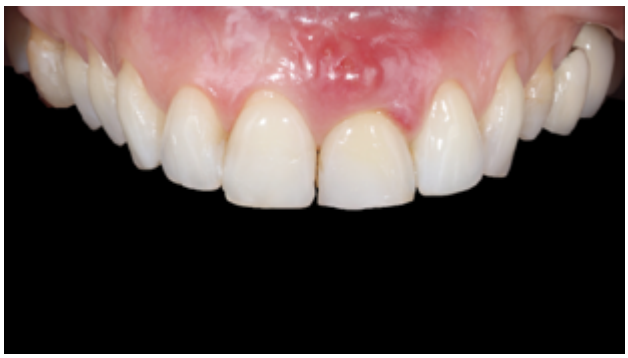


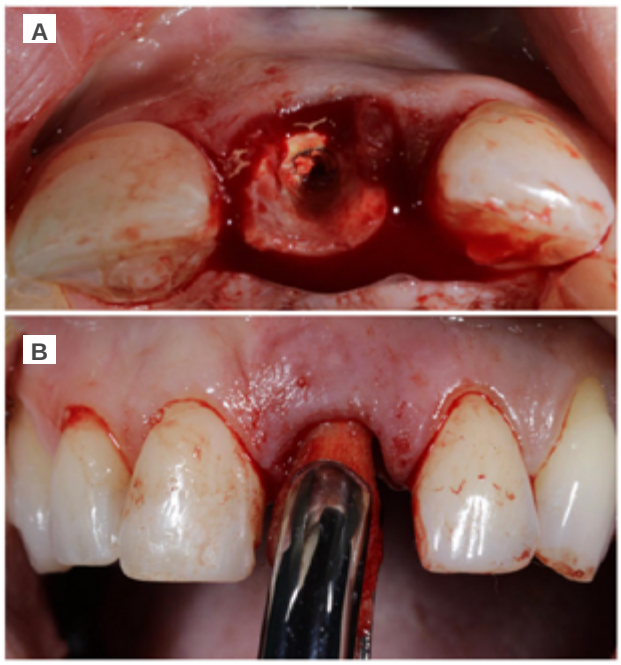
Figure 1. Front intraoral photograph of the patient. Multiple gingival recessions can be observed as well as an area of greater volume, erythematous and oedema at the bottom of the vestibule and adhered mucosa corresponding to the ULCI (2.1), compatible with a periodontal abscess.

Figure 2. Parasagittal section explored in CBCT. A fracture can be seen whose extension compromises the coronal structure and the first coronal third of the incisor.

Surgical approach

Under local anaesthesia (articaine 4% 1:100,000 adrenaline) with an infiltrative technique at the level of the vestibular fundus of the maxillary anterior region (anterior superior alveolar nerve) and palatine region (nasopalatine nerve), the coronal fragment of the ULCI was extracted before taking out its root (Figure 3A). A syndesmotomy of the surrounding soft tissue was performed for this, to establish the condition of the vestibular cortical bone by palpation. After that, the root was extracted in a controlled manner to minimise trauma, by first dislocating it with a periotome and subsequent controlled gripping with forceps (Figure 3B).

Using a Lucas-type curette spoon and a CP12 periodontal probe, the state of the alveolus was



Figures 3A and 3B. A: Surgical moment of tooth extraction. Extraction of the previous tooth crown and visual examination of the root.
B. Forceps grip of the upper incisors after dislocation of the tooth by a periotome, with the adjacent soft and hard tissues preserved by a syndesmotomy beforehand.

checked and found to be completely intact, except for the vestibular region, where there was a defect in the coronal-apical direction of 4 mm (Figure 4).

The provisional Maryland-type prosthesis was used as a provisional device and surgical guide to guarantee the correct vestibulo-lingual position of the OII, according to the plan devised, thus preventing any future problems at the prosthodontic level or in the integrity of the soft and hard tissues of the vestibular region (Figures 5A and 5B).

The drilling protocol was followed for the placement of the OII through the surgical guide, with its correct 3-dimensional position being checked at all times (Figures 6A, 6B and 6C).

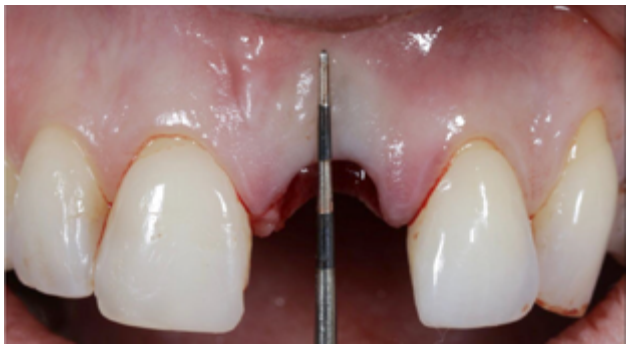
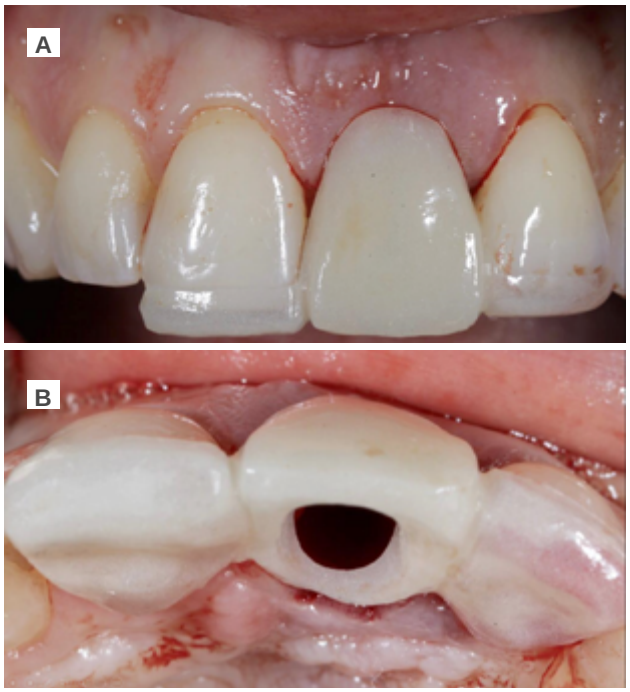
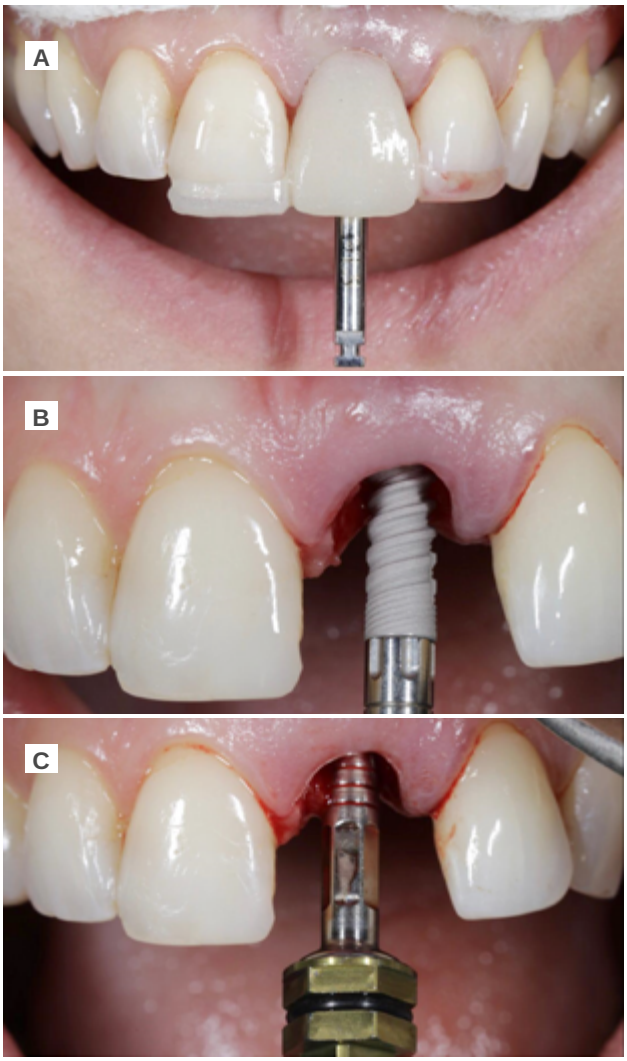


Figure 4. Note ischaemia in the vestibular gingiva that slightly displaces the gingival margin towards the lingual derived from the absence of coronal vestibular cortical as a result of the evolution of the infectious process and the state of the tooth.

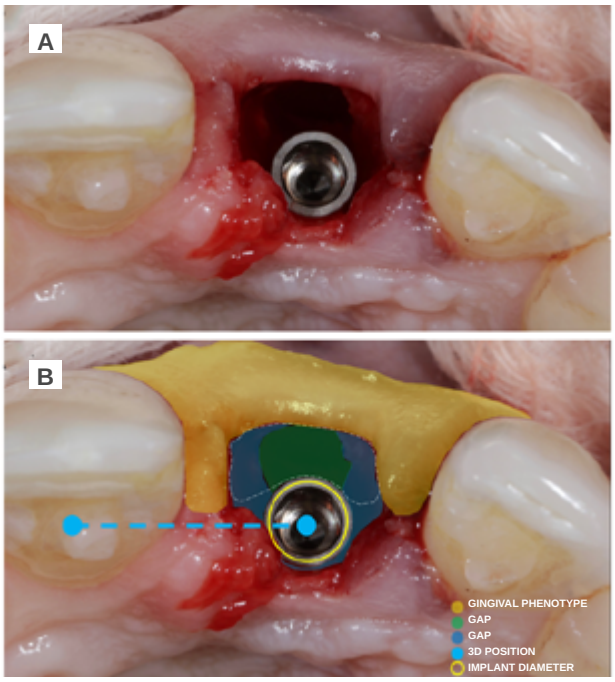


Figures 5A and 5B. A: Modified Maryland-type acrylic prosthesis extensions to incisal edges and palatal aspect of adjacent teeth (1.1 and 2.2), frontal photograph.
B. Maryland-type acrylic prosthesis. Occlusal image. The palatal extensions to adjacent teeth can be observed, as well as a hole in the cingulate region of the provisional prosthesis, to allow perioperative handling, such as a surgical splint during the drilling phases.



Figures 6A, 6B and 6C.
A. Arrangement of the initial surgical drill.
B. Insertion of the dental implant after drilling guided by the provisional prosthesis as a surgical guide.
C. Manual establishment by an implant carrier of the ideal coronal-apical position for the correct evolution of the future prosthesis and soft and hard tissues.

The OII (Neo AlphaBio Medical10™ 3.25mm x 11mm) was inserted at a depth with respect to the future gingival margin that needed to be achieved, 4 mm away from the shoulder of the OII. In this case, the reference gingival margin was that of the ULCI itself, since it was intact and unchanged; while, in the case of the URCI, there was a gingival recession of 2 mm. In this process, the choice of OII diameter was taken so that a space or "gap" would be obtained to facilitate reconstruction of the vestibular cortical bone, paying special attention



Figures 7A and 7B. A: Occlusal photograph of the dental implant placed after dental extraction. B. Details of surgical aspects to highlight during the planning of the clinical case.

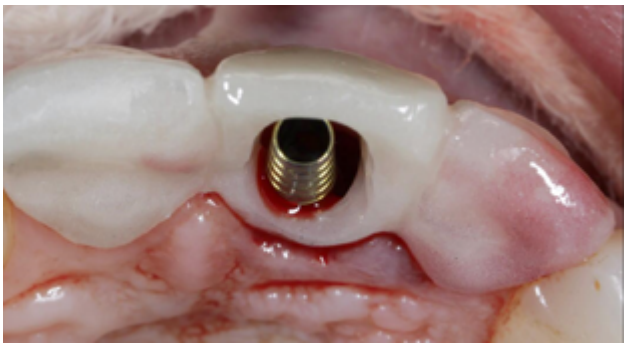


Figure 8. Checking proper emergence of the implant and the abutment screwed to it through the hole in the provisional prosthesis. A gold anodised titanium abutment can be seen for subsequent carving and splinting with the provisional prosthesis.

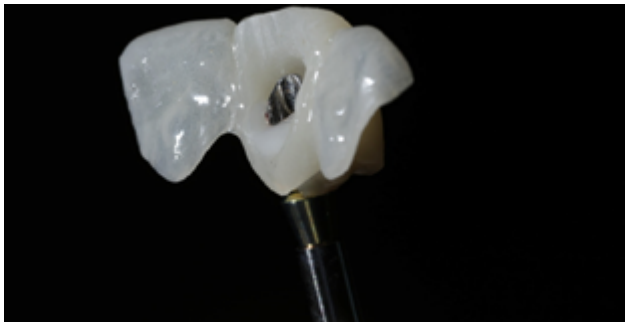


Figure 9. Close-up showing the provisional acrylic prosthesis features, cemented to the provisional abutment.

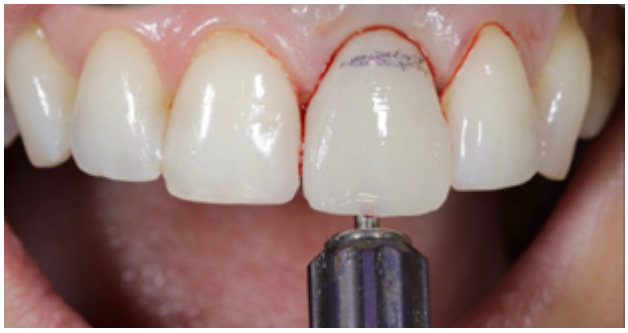
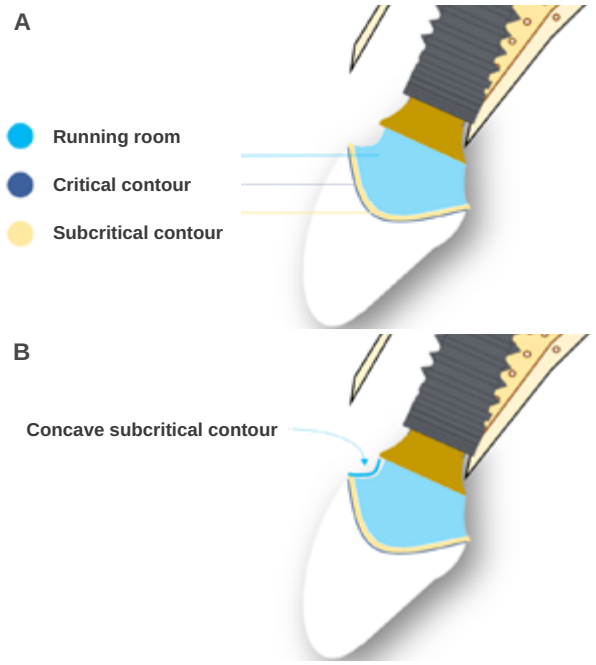


Figura 10. Prótesis provisional atornillada al implante. Se han eliminado las aletas adyacentes a la corona principal. Se realiza un registro mediante un lápiz quirúrgico del hipotético margen gingival para establecer el contorno crítico y el contorno subcrítico.



Figures 11A and 11B. A: Close-up of the morphology of the provisional crown. Zones corresponding to the critical, subcritical and running room regions are indicated.
B. Close-up of highly concave subcritical profile

to the gingival phenotype, to allow for management of the soft tissues also (Figures 7A and 7B).

Primary stability was obtained, achieving anchorage in the palatal residual bone at an insertion torque of 35 N/cm^2. Subsequently, a temporary prosthetic abutment was placed.

Provisional prosthetic phase

Before starting the provisional screw-retained restoration on the OII, the correct position of the abutment in terms of the provisional prosthesis was verified. The abutment was relined with the provisional through the use of flowable composite (Figures 8 and 9).

Preparation of the emergence profile

To perform the emergence profile (EP), the ideal position of the gingival margin was determined, which had to coincide with the position of the cervical line (amelocemental junction) of the ULCI (Figures 10-13B).

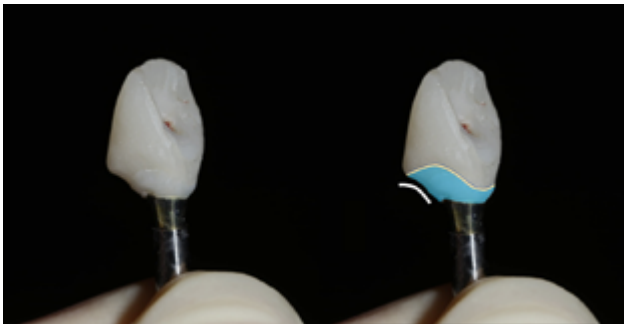
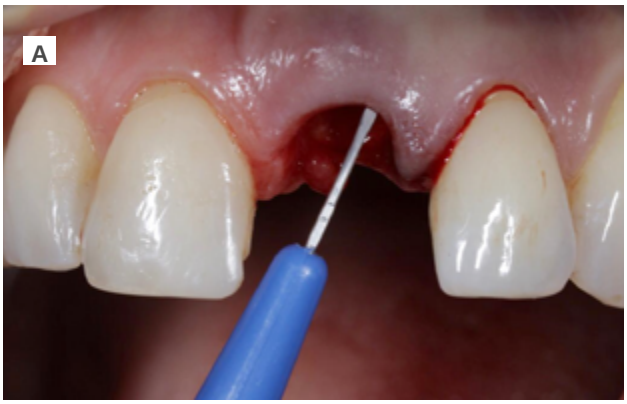
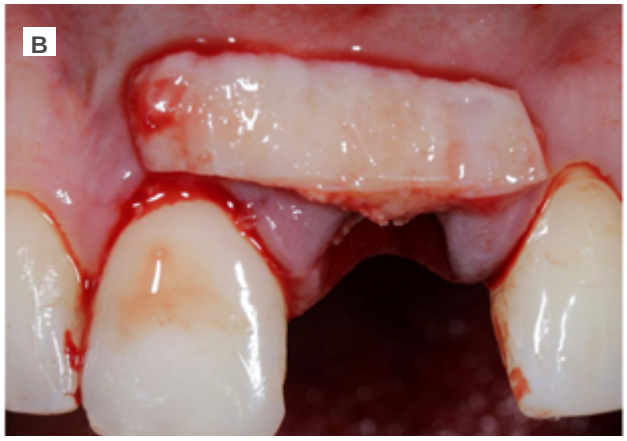
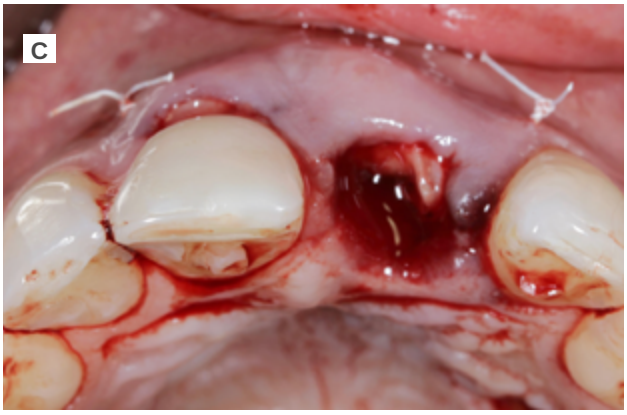


Figure 12. Close-up of the provisional prosthesis with the proper subcritical contour morphology.

Figure 13. Placement of provisional prosthesis screwed to the implant, side view.







Figures 14A, 14B and 14C.
A. Partial-thickness incision preparing the receiving bed for a soft tissue graft for insertion into the tunnel formed.
B. Close-up of the connective tissue graft of palatal origin whose length can be seen. It includes the alveolus of both teeth 2.1 and 1.1 to improve the gingival biotype and reduce the gingival recession in tooth 1.1.
C. Tunnelled connective tissue graft fixed with PTFE suture in mesial and distal. The perioperative soft tissue volume can be seen.

Soft and hard tissue management

In these types of cases, the management of hard and soft tissues takes on special importance.

The recipient area was prepared for the approach using the pouch and tunnel technique. A full-thickness incision was made through the vestibular region of the alveolus resulting from the extraction. This fan incision was made with the use of a crescent knife and tunneller. The corona region of the incision was made at full thickness, but the mesial and distal region that compromised the inserted mucosa of teeth 22 and 11 were made at partial thickness; this same plane was maintained in the apical region of the ULCI area.

The donor area was then approached, for which a graft was taken that comprised epithelial tissue and connective tissue (free gingival graft), approximately 2.5 mm thick from the palatal region of the left hemimaxilla, encompassing the premolar and molar region of this zone. This approach was chosen due to the greater guarantees regarding the quality of the connective tissue graft (CTG) when its de-epithelialisation takes place outside the mouth due to the maintenance of the lamina propria.

Due to a 2 mm gingival recession in the URCI, the CTG obtained was of sufficient size to encompass the region of this tooth and to be able to treat this recession simultaneously with the OII procedure. It was adapted to the recipient region with a 5.0 polytetrafluorethylene (PTFE) suture with mesial and distal fixation points, which guaranteed proper vascularisation of the graft (Figures 14A, 14B and 14C).

Subsequently, to guarantee the stability of the soft tissues and to anticipate the remodelling of the hard tissue resulting in vestibular defects, bone preservation of the vestibular region of the alveolus was carried out. A collagen-reinforced bone xenograft (Bio-Oss™ Collagen, Geistlich) was used, which was placed in the gap between the vestibular cortical bone and the implant itself (Figure 15).

To complete the surgical approach, the provisional prosthesis was placed with the already made PE and 3 points of coronal traction were carried out, anchoring them to the contact points of the provisional and adjacent teeth with a 6.0 monofilament suture (Figure 16).

Evolution

The first review of the surgical procedure was carried out 7 days later. Proper initial healing of the soft tissues and a lack of infectious or inflammatory pathology were

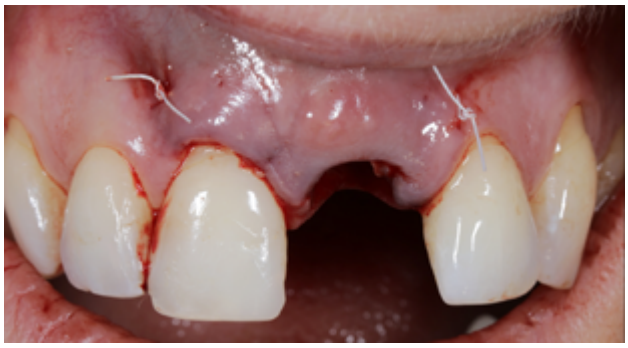


Figure 15. Frontal close-up of the fixed connective tissue.

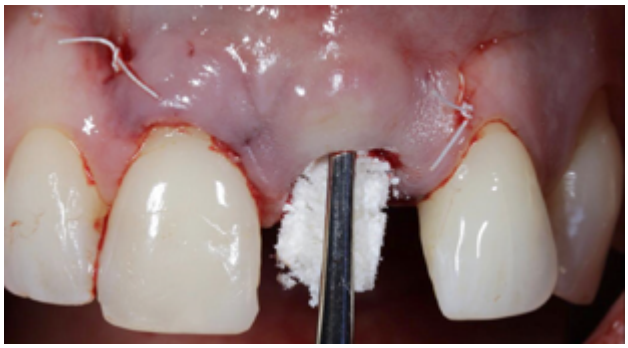


Figure 16. Inserting the particulate xenograft during surgery.

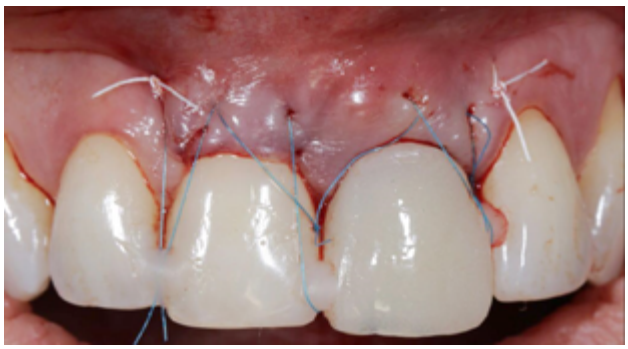


Figure 17. Teeth anchored stitching to maintain the soft tissue in a coronal position.

observed (Figure 18). At 14 days, a second review was performed when the suture was removed (Figure 19). The review one month after surgery showed proper initial stability of the soft and hard tissues, as well as the absence of any signs related to the failure of the procedure (Figure 20).

At 4 months, good stability of the OII was seen as a result of the proper osseointegration process. For the soft tissues, a decrease in the volume of the interdental papilla could be seen (Figure 21). Given the absence of signs and symptoms and the proper osseointegration of the OII, the subcritical profile was modified to improve the arrangement of the gingival soft tissue and promote recovery of this papilla (Figures 22 and 23).

At 6 months, proper arrangement of the soft tissues could be seen, with their stability over time due to their handling through the provisional prosthesis (Figure 24).

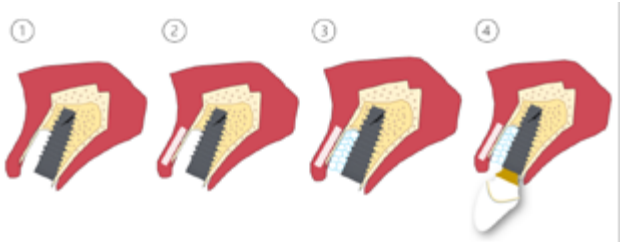


Figure 18. Summary of the 4 surgical steps performed during the procedure: 1. Insertion of the dental implant in the favourable 3-dimensional position for prosthodontic rehabilitation; 2. Connective tissue graft; 3. Xenograft placement with high collagen content; 4. Sealing of the post-extraction alveolus and provisionalisation of the implant when screwing the corresponding prosthesis.

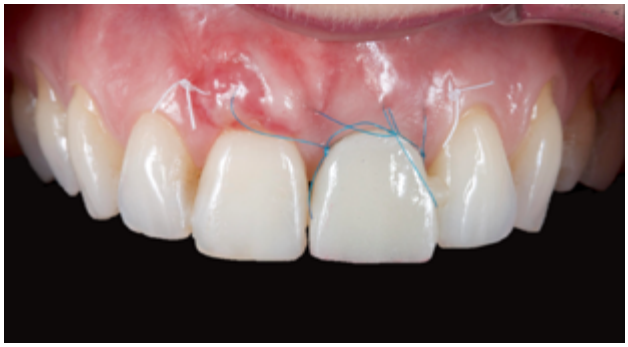


Figure 19. Frontal intraoral view that reflects the condition 7 days after surgery. The decrease in tension of the suture used can be observed after the absence of inflammation and initial healing of the soft tissue.

A radiological check was also carried out to determine the status of the hard tissues (Figure 25).

Given the good evolution at 6 months, the position of the OII and the emergence profile were recorded via an individualised transfer to replicate the gingival

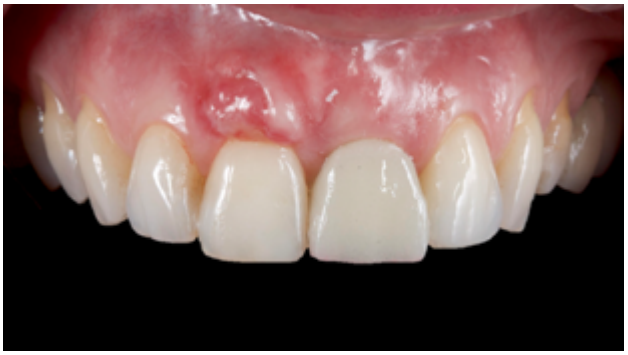


Figure 20. Frontal intraoral view showing satisfactory evolution. Slower healing is observed in the region of tooth 1.1. The presence of residual epithelial tissue is suspected, related to an increase in inflammatory processes around that area.

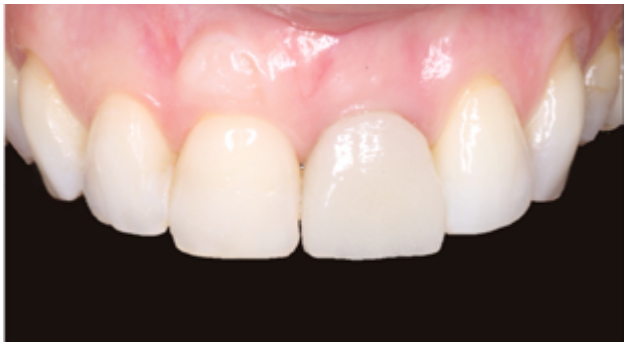


Figure 21. 30 days after the surgical procedure. No alterations compatible with signs of infection or failure of the procedure are observed.

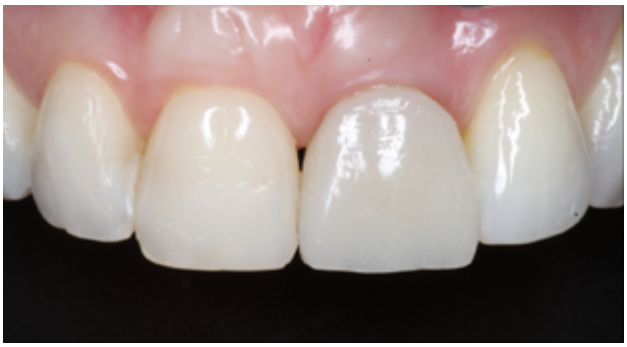


Figure 22. 4 months after implant placement. There are no signs of failure. The examination shows a decrease in the height of the midline papilla.

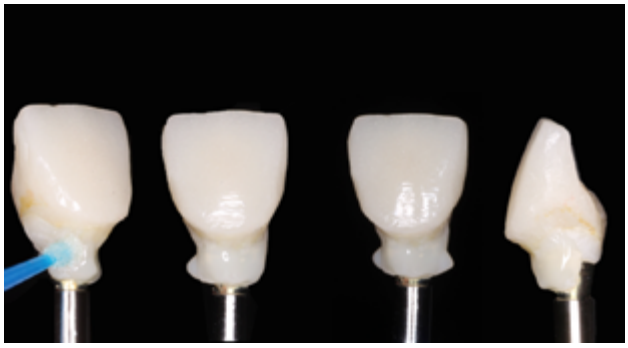


Figure 23. Provisional prosthesis subjected to increases in resin in the subcritical area to promote proper arrangement and volume of the soft tissue.

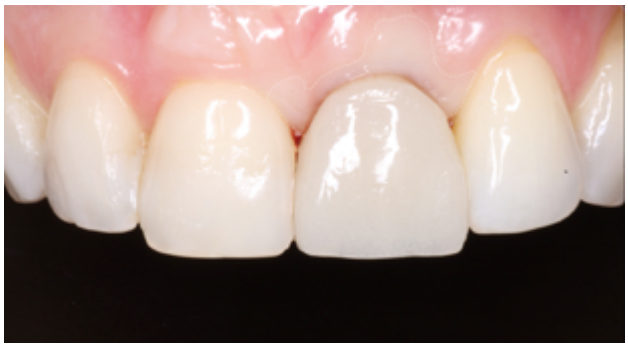


Figure 24. Frontal view with delimited area of ischaemia, as a result of modifying the emergence profile of the provisional prosthesis.

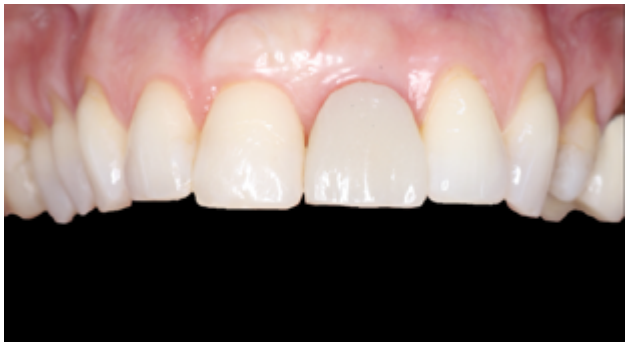


Figure 25. 6 months after the intervention. Favourable arrangement of the soft tissue can be observed.

architecture faithfully and in detail (Figures 26 and 27). The final fixed prosthesis screwed to the OII was inserted 7 months after the treatment had started (Figures 28 and 29).

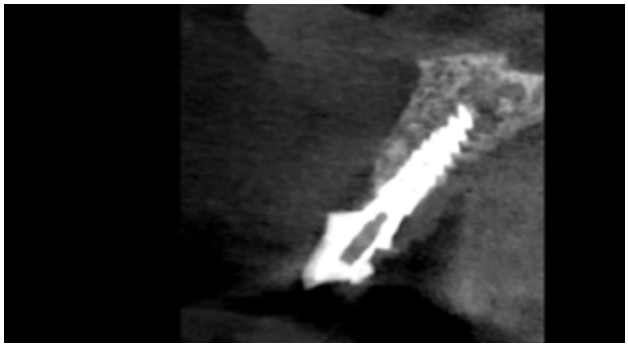


Figure 26. Study with CBCT to assess the condition of bone tissue. No evidence is seen of pathological signs or alterations related to treatment failure.

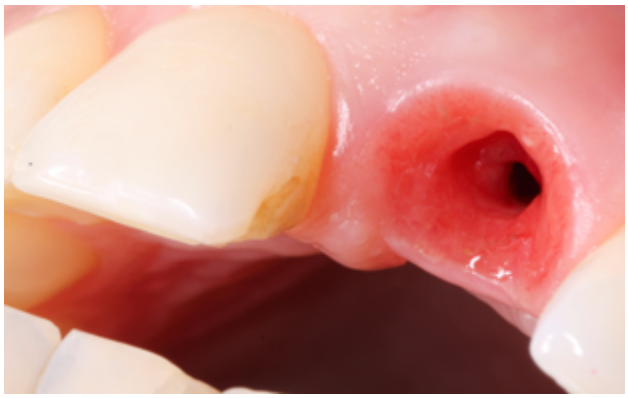


Figure 27. Magnified to show a close-up of the emergence profile. The acquired shape of the soft tissue surrounding the provisional prosthesis and running deep towards the implant connection can be seen. Adivergent tissue distribution from the implant to the outside is seen, promoting proper biological sealing of the implant.

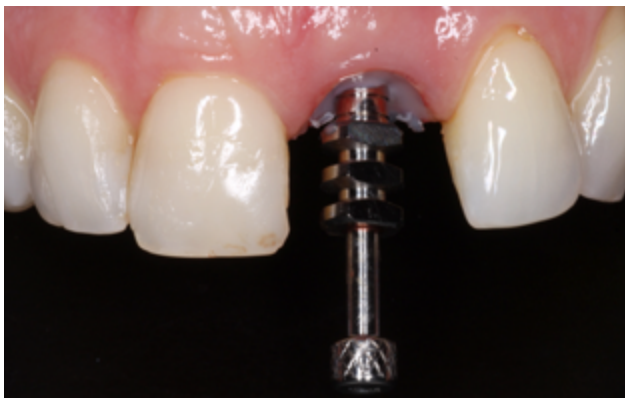


Figure 28. Recording of the 3-dimensional implant position and replica of the emergence profile using a customised carrier.

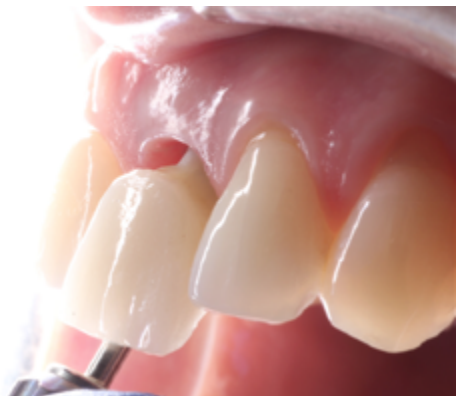


Figure 29. Finished crown placement.

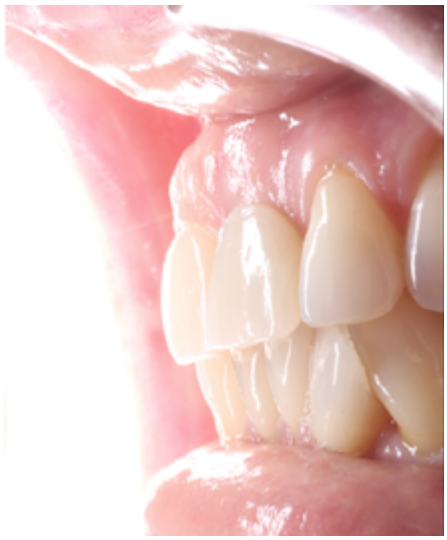


Figure 30. End of treatment.

DISCUSSION

The current trend in the field of implantology has been an evolution from conventional loading of the OII to immediate loading, due to the greater functional and aesthetic demands of society and patients[12,13].

The benefits of immediate loading include a notable reduction in surgical interventions, a shorter time delay in treatment and better psychological and social wellbeing for the patient[12].

Among the success factors that influence immediate loading are the primary stability of the implant, the presence of micromovements, the surface and size of the implant, the quantity and quality of bone, the insertion torque, the occlusion, patient habits, local and systemic factors and the type of prosthodontic rehabilitation[12,13].

Some authors believe that micromovements of less than 30 microns do not influence the osseointegration phase of the OII, with it being suggested that micromovements up to 100 microns have no negatively effects; in fact, movements of 60- 90 microns can promote higher bone density around the OII. The insertion torque of the OII must be at least 30-40 N// cm[2. 12-14].

These requirements for implant loading generally become more difficult to obtain when the implant is placed in a socket immediately after tooth extraction, due to less residual bone presence. The immediate or early placement of an OII is widely supported by the literature, with no significant differences during osseointegration. Therefore, the placement of a post-extraction implant and, in turn, its immediate loading, represent a considerable reduction in treatment times while obtaining immediate aesthetic benefits and function[12-15].

To date, there are studies that highlight the greater risk of failure in single implants subjected to immediate loading compared to multiple implant restorations, even obtaining a high insertion torque. Therefore, the concept of “loading” has changed to that of “provisionalisation”, since the provisional crown is completely exempt from function. The importance of these provisional restorations, in addition to immediate aesthetic benefit, lies in the maintenance of the emergence profile similar to the anatomy prior to extraction, as well as the gingival contour and interdental papillae; thus favouring the maintenance of volume and reducing collapse due to tooth loss[12-15].

According to different studies, these restorations also stabilise the clot that minimises the loss of the cortical bone of the vestibular region when combined with non-resorbable grafts. The modification of the critical and subcritical contour, concepts described by Su et al. in a second phase, prior to making the final prosthesis,

allow the gingival contour to be shaped until the ideal architecture and aesthetics are achieved[16].

Regarding the placement of graft material in the gap between the implant and the vestibular bone, there are studies that support the use of a non-resorbable bone graft due to contributing to compensating for the contraction of the marginal ridge; thus preserving the alveolar contour prior to tooth extraction to a greater extent.. A gap greater than 2-3 mm between the OII and the vestibular cortical bone would facilitate the formation of a blood clot that would subsequently differentiate into new bone. Studies comparing filling and not filling the gap with different materials (autologous bone, xenograft or alloplastic grafts) have highlighted significant differences in terms of less vestibular collapse in the study groups in which a sufficient gap was respected for clot formation next to the graft with a non-resorbable material, such as xenogenic or alloplastic materials based on hydroxyapatite.

A summary of the essential points to consider for the placement of post-extraction implants in aesthetic cases follows:

Residual bone

This is the key point for the placement of the OII. It can be inserted if there is sufficient residual bone to place and prosthetically guide it in the correct 3-dimensional position. In the anterior sector, the area corresponding to the apico-palatal zone of the alveolar bone is the anchorage region for the OII. According to Kan et al., 81% of the alveoli (class I alveoli according to their classification) have a sufficient amount of apical-palatal bone to insert the implant in an ideal prosthetic position[22]. Not having sufficient residual bone in the ideal prosthetic position contraindicates the treatment, and alveolar preservation or reconstruction with delayed placement of the OII[7] would have to be considered.

Gingival margin

In cases where there is a recession greater than 4 mm, it will be decided to defer the immediate placement of the implant, since this situation is accompanied by a complete or almost complete defect of the vestibular cortical bone, which must be reconstructed beforehand. This is because there is also usually significant soft tissue loss which will decrease the predictability of the treatment. Authors such as Da Rosa et al. have proposed the vestibular reconstruction technique of hard and soft tissue at the same time as immediate placement of the OII. However, this is a complex technique, dependent on the donor area, and there is currently not enough scientific literature to evaluate its results[23].

Defects in the vestibular cortical

As long as the previous points are favourable, any fenestrations or dehiscences in the vestibular cortical bone will not contraindicate immediate placement of the implant with its subsequent provisionalisation. If there are significant defects of more than 5 mm, in addition to the graft material in the vestibular gap, a native collagen membrane between this graft and the soft tissue will need to be interposed, according to different studies, to promote proper regeneration of the vestibular bone volume and prevent the invasion of epithelial cells[19,24].

Periodontal phenotype

The knowledge and importance of the quality of the periodontium, and, therefore, of the soft tissue surrounding the tooth or implant, has undergone a metamorphosis over time. Some authors have already found that the morphology of the dental crown and the clinical features of the periodontium have a certain relationship[25]. The same author had previously observed that certain forms of the clinical crown were closely related to the appearance of gingival recessions, especially in cases where the crown coincided with an

elongated and narrow appearance, compatible with what today would be a thin gingival biotype[25].

However, the last workshop on the classification of periodontal and peri-implant diseases and conditions in 2017 suggested the periodontal phenotype - a term that encompasses gingival phenotype (gingival volume) and bone morphotype (thickness of the vestibular cortical bone) - as the best way to evaluate the different aspects around the old term of gingival biotype. There are certain aspects of the gum that are not limited to gingival thickness, but that bone volume is also a determining factor. In the present clinical case, during the periodontal probing, the probe was visible, which suggests a thickness of less than 1 mm and a discrete volume of the vestibular bone region was observed in the tomographic study[26,27].

This periodontal aspect had been studied previously in a publication by Müller et al., in which it was indicated that the "gingival phenotype" responded to the dental shape, again to the gingival biotype and the degree of keratinisation of the gingiva[28].

A notable feature of soft tissue that has not yet been conclusively revealed in the scientific literature is whether the presence of tissue with a certain degree of keratinisation around the implant is a prognostic factor for it. The clinical evidence may be suggestive of this, as seen in clinical studies from the 1990s[28]; although current systematic reviews have not highlighted the results of these clinical studies[29]. There should be further in-depth study of this aspect; however, a recent study suggests that the presence of more than 1 mm of keratinised gingiva is not a significant factor in the probability of the appearance of peri-implantitis, giving the prominence of the appearance of this pathology to other factors[30].

That is why this clinical case raises special complexity if the aspects present regarding the patient's periodontal phenotype are considered, whose features imply proper management of the soft tissues, evaluating the placement of a connective tissue graft simultaneously with the placement of the OII. The latter is to prevent the appearance of soft tissue defects in the long term and, therefore, aesthetic complications and those of the implant itself that may occur in the future[31,32].

CONCLUSIONS

Rehabilitation on implants in dental loss situations in the aesthetic anterior sector, especially in young patients, requires a multidisciplinary treatment plan for tooth extraction and placement of the OII in the proper 3-dimensional position, with different aspects to be taken into account for this. Especially important are the residual bone present, the position of the gingival margin and the preservation and conditioning of the peri-implant hard and soft tissues. This is done by means of grafts and proper handling of a provisional prosthesis, until an emergence profile and ideal gingival contour are achieved before the final crown.

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Clinical case

Conservative approach in a patient with multiple radiolucent periapical lesions using endodontics and surgery

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ABSTRACT

Case report of a 43- year old male patient with multiple periapical radiolucent lesions caused by endodontic failure in teeth supporting a metalloceramic prosthetic rehabilitation, who came to the clinic to assess the possibility of keeping his teeth.

After clinical and radiological examination with periapical x-rays and cone beam computer tomography (CBCT), we decided to use a combined endodontic-surgical approach.

Clinical evolution was favourable, and the radiographic and tomographic controls showed complete healing of the periapical radiolucent lesions.

Endodontic retreatment combined with periapical microsurgery are effective tools for conservative treatment of teeth with periapical lesions caused by endodontic failures.

KEYWORDS

Periapical lesion; Root canal treatment; Periapical surgery; Guided bone regeneration.

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CLINICAL CASE

A 43-year-old male patient, with no relevant medical history and prosthetic rehabilitation using intraradicular posts and metal-ceramic crowns from 16 to 26, who came to the clinic due to recurrent infections and fistulas in the anterosuperior sector and 25-26 zone. The patient had had the extraction of all of them proposed to him, with the placement of implants, but wanted to assess the possibility of keeping his teeth.

The patient provided an orthopantomography (OPG) as a radiological study (Figure 1). Periapical radiographs (Figures 2 and 3) were performed and a clinical examination including periodontal assessment of the affected teeth, without observing increased probing depths that could indicate the existence of endoperiodontal lesions.

To confirm the endodontic origin and the size of the lesions, tomographic examinations were performed with a slice thickness of 75 microns using CBCT CS8100 (Carestream Dental™), in which radiolucent periapical lesions were observed at the level of 12, 11, 21 (with bicortical involvement), 25 and vestibular roots at 26 (Figures 4 to 8).

The patient was informed about his dental situation, and consent was obtained to perform apical microsurgery for three upper incisors (12, 11 and 21) and the need to use guided bone regeneration techniques (GBR) in 21.

Meanwhile, the vestibular roots of 26 showed clearly deficient root canal treatment, being underextended by several millimetres, as well as an omitted mesiopalatine canal (MP). Therefore, the need to repair the root canal treatment was proposed to the patient before performing microsurgery on tooth 25 (Figure 9).

Periapical microsurgery was performed under magnification using an operating microscope (Kaps™) at the level of the upper incisors. Access to the apical lesions was achieved after a modified Neumann incision. Once these lesions were eliminated by dental excavation and curettage, apicectomies were performed, removing the last 3 mm of each root, and retrocavities 3 mm deep using ultrasound (Newtronc, Satelec) and obturation using bioceramic cement (Biodentine™, Septodont) were performed. In 21, a collagen membrane (Bioguide™, Geistlich) was placed in the palatal fundus and the defect was filled with porous bone matrix of bovine origin (BioOss™, Geistlich) before placing a new collagen membrane on the vestibular and suturing the flap using simple stitches with 5/0 Polyamide monofilament (Supramid™, Braun).

Subsequently, the canals of the buccal roots of 26 were retreated, performing a coronal access through the

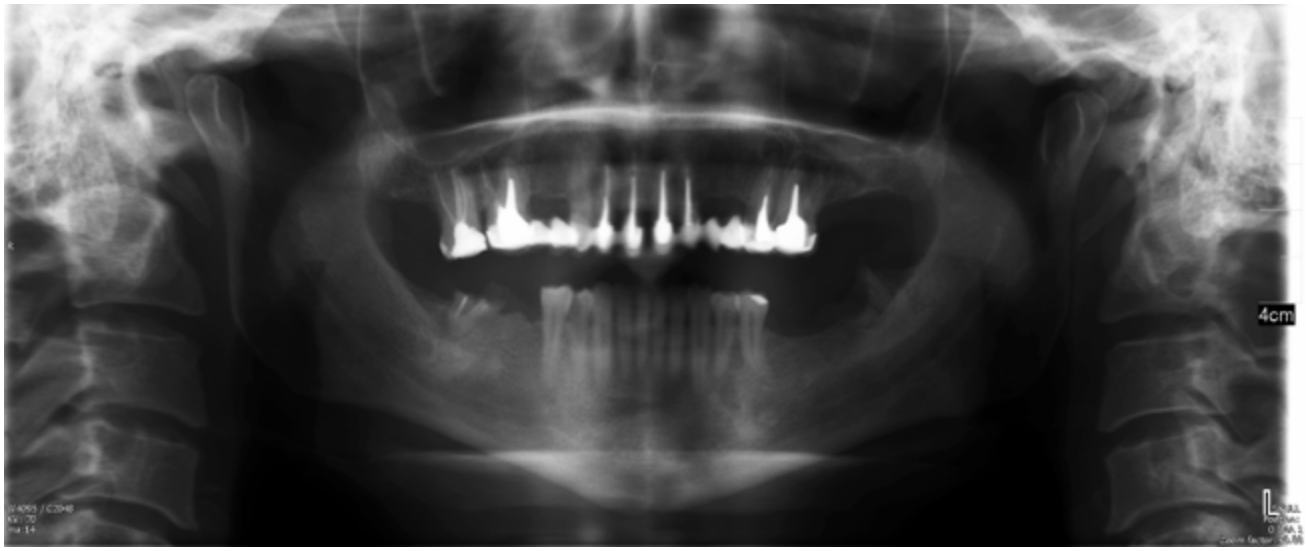


Figure 1. Orthopantomography provided by the patient at the first visit.

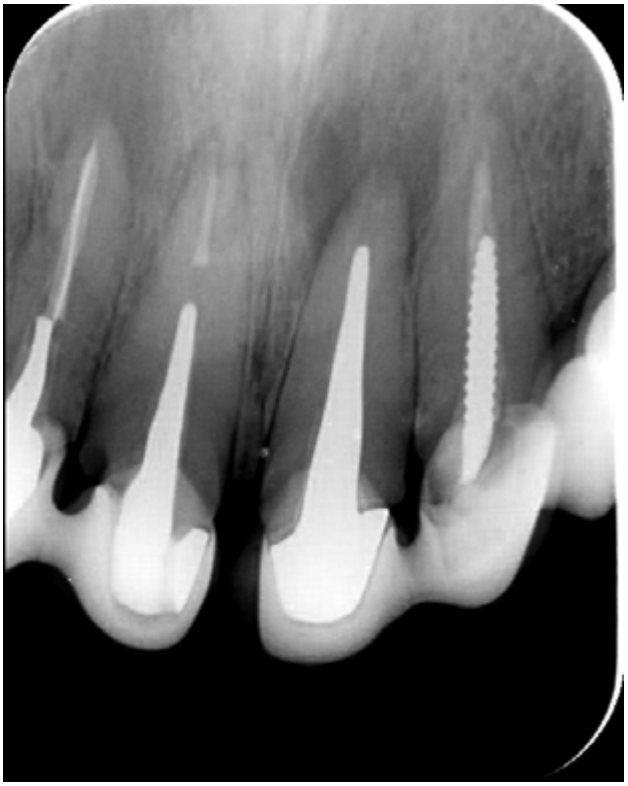
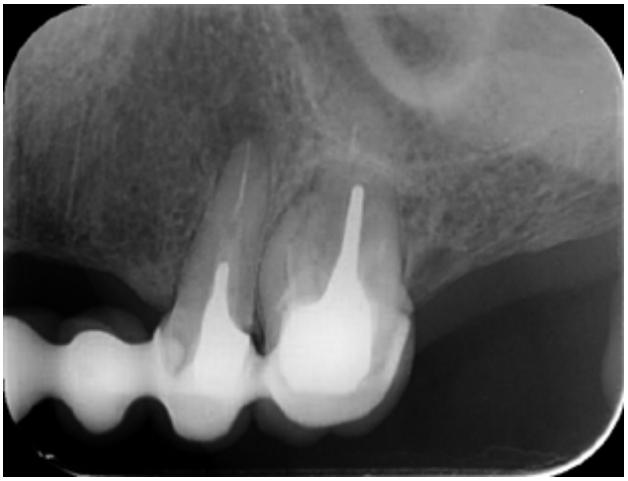


Figure 2. Preoperative periapical radiograph of upper incisors.



Preoperative

crown, eliminating part of the cast stump, locating the omitted MP canal and unobturating the mesiobuccal (MB) and distobuccal (DB). Once these canals were disinfected and shaped, they were filled with bioceramic sealing cement (BioRoot RCSTM, Septodont) and gutta-percha.

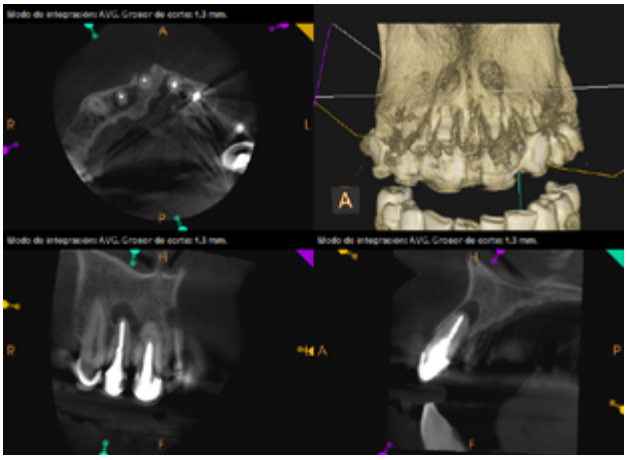


Figure 4. Preoperative tomographic image at level 12.

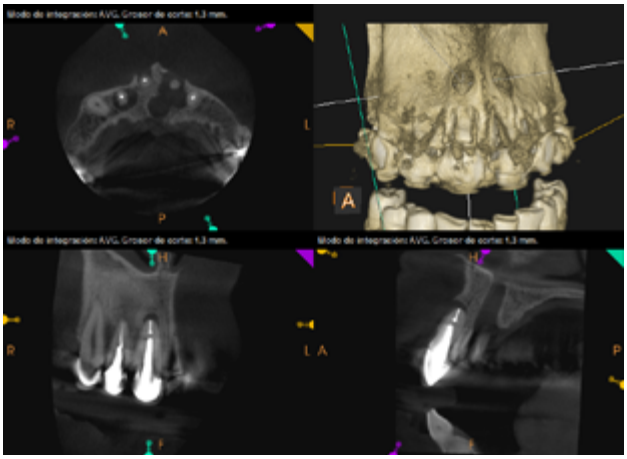


Figure 5. Preoperative tomographic image at level 11.

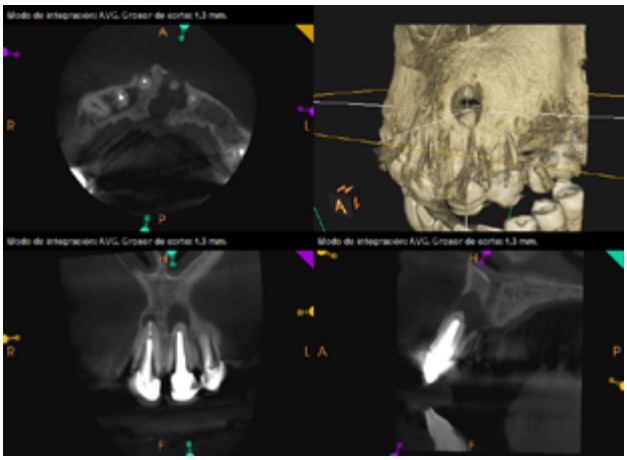


Figure 6. Preoperative tomographic image at the level of 21 in which the bicortical extension of the defect and its relationship with the nasopalatine duct can be seen.

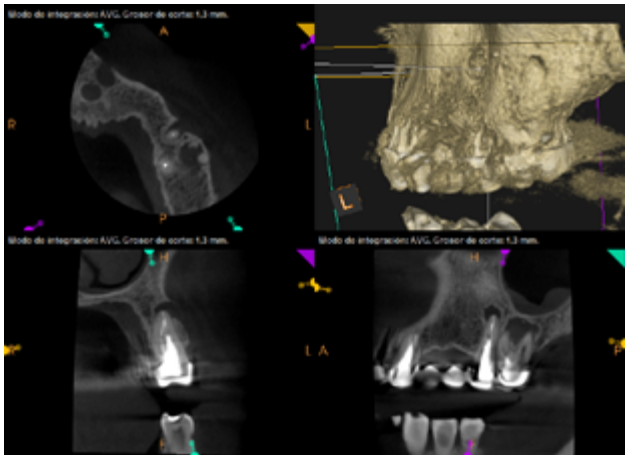


Figure 7. Preoperative tomographic image at the level of 25 and 26.

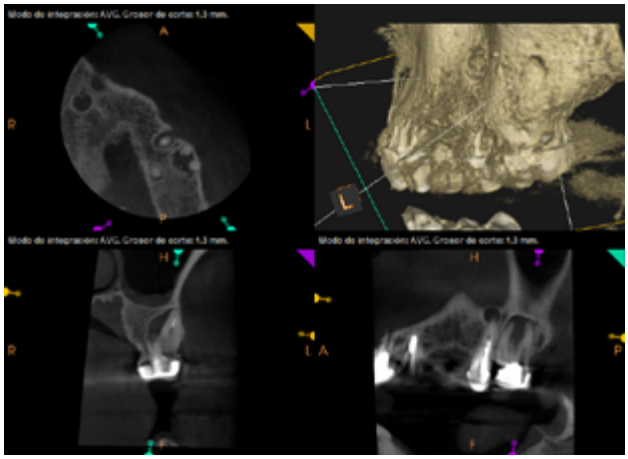


Figure 8. Preoperative tomographic image at the level of 26, showing underfilling of the mesiobuccal and distobuccal ducts

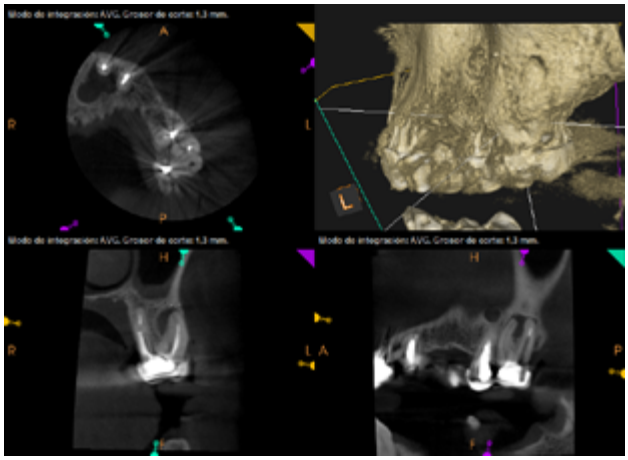


Figure 9. Preoperative tomographic image at the level of 26 in which it can be seen that the mesiopalatine canal is omitted.

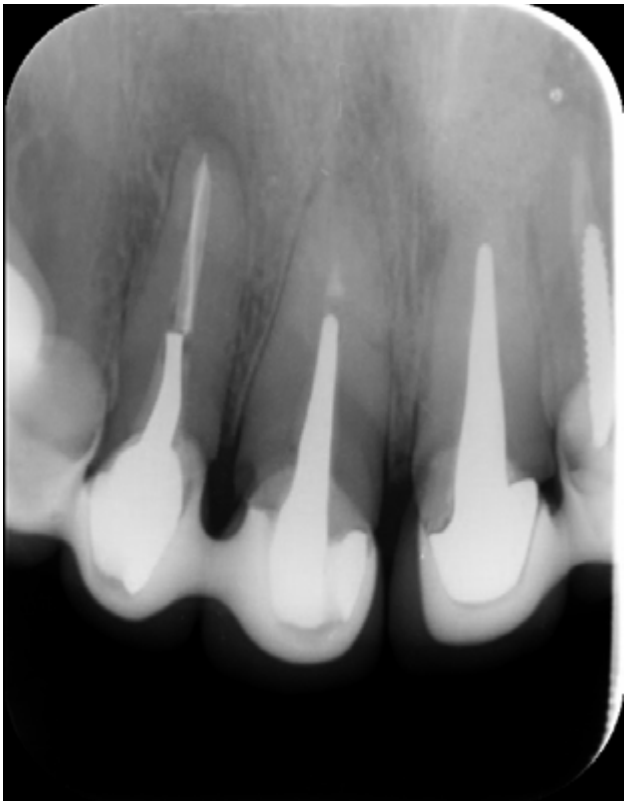


Figure 10. Control periapical radiograph at 6 months, after microsurgery of the upper incisors.

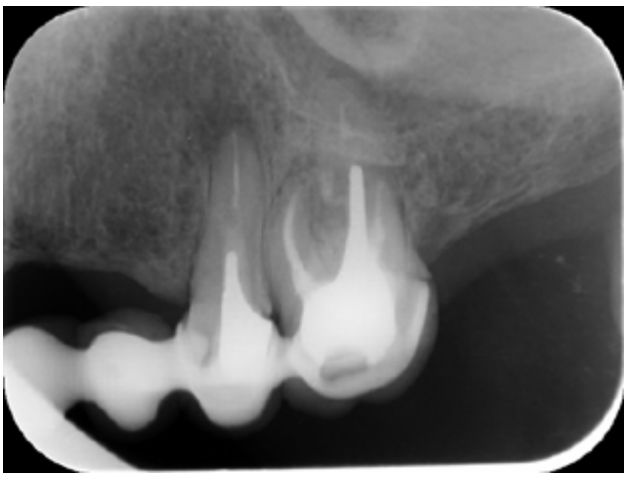


Figure 11. Control periapical X-ray at 6 months, after retreatment of ducts at 26.

Six months later, the patient went for a check-up without any symptoms, both anteriorly and posteriorly. Periapical radiographs showed a decrease in the size of the pre-existing radiolucent periapical lesions (Figures

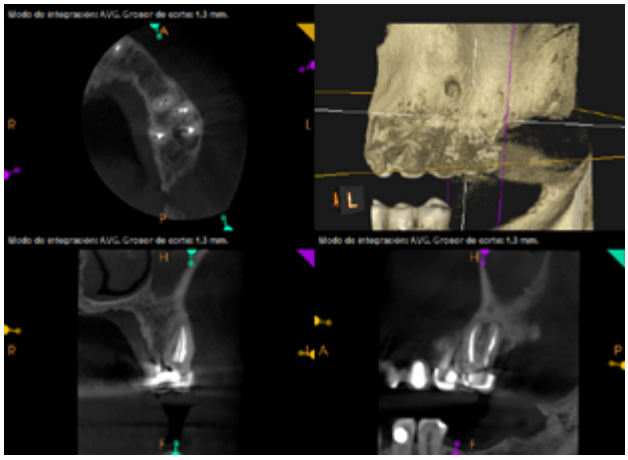


Figure 12. Control tomographic image 6 months after retreatment of the 26 root canals, showing a clear decrease in the size of the pre-existing periapical radiolucent lesion.

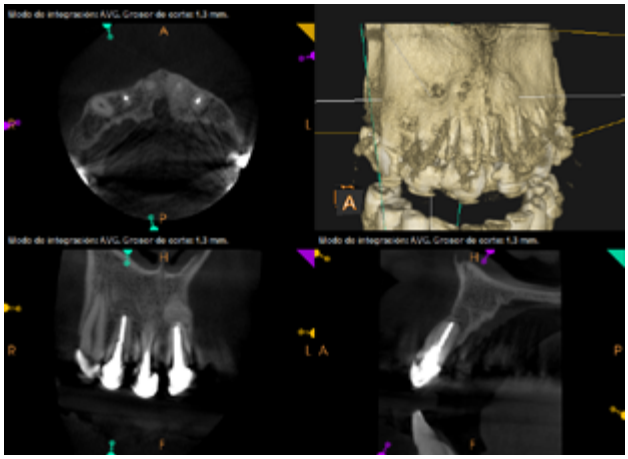


Figure 13. Control tomographic image at the level of 12, 18 months after periapical microsurgery in which the resolution of the pre-existing periapical radiolucent lesion can be seen.

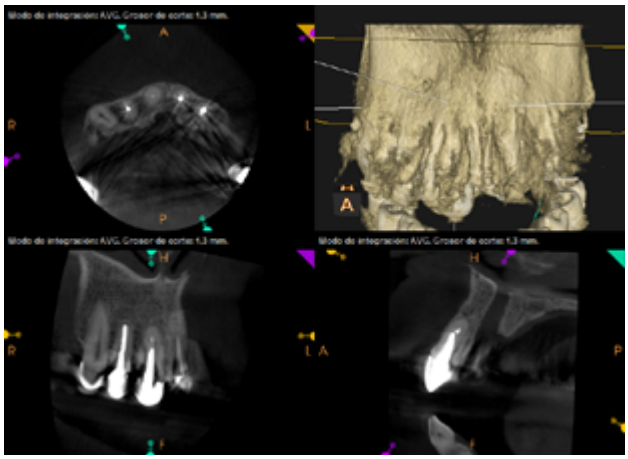


Figure 14. Tomographic image to check at level 11, 18 months after the periapical microsurgery in which the resolution of the prexisting radiolucent periapical lesion can be seen.

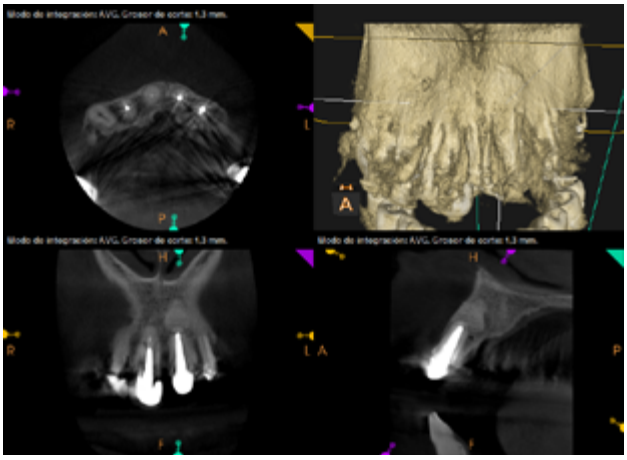


Figure 15. Control tomographic image at the level of 21, 18 months after periapical microsurgery with guided bone regeneration; healing of the pre-existing periapical radiolucent lesion can be seen.

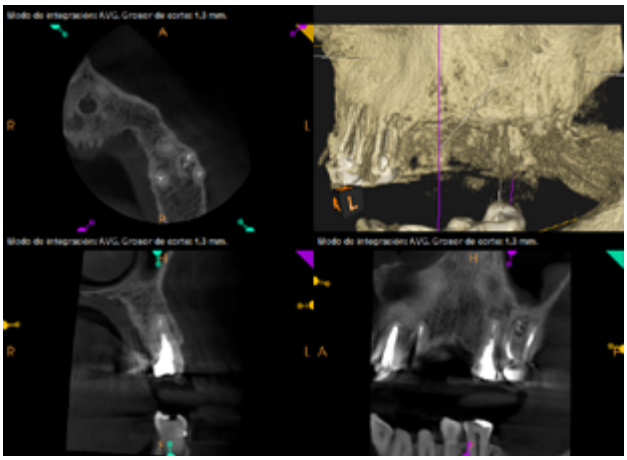


Figure 16. Control tomographic image at the level of 15, 12 months after periapical microsurgery in which the resolution of the pre-existing periapical radiolucent lesion can be seen.

10 and 11). Given that the lesion on 25 remained to be treated, a control CBCT was performed where improvement at the level of 26 was verified (Figure 12), so microsurgery on 25 was scheduled.

After the microsurgery was performed on 25, the patient had no symptoms and the control tomographies at 12 months (in 25) and at 18 months in the remaining teeth showed regeneration of pre-existing radiolucent periapical lesions on all treated teeth (Figures 13 to 16).

DISCUSSION

For proper diagnosis of radiolucent lesions at the periapical level, it is important to have radiological images that accurately show their location and size. In our case, the patient provided an orthopantomography; however, this type of radiography is not suitable for diagnosis in endodontics. The periapical radiography provides better definition, especially at the anterior level, as it is less distorted. CBCT is currently the most reliable radiological test, since it provides 3D images, which help to give a more accurate diagnosis[1,2].

When there are teeth failures after numerous previous treatments, as in the case described, it is important to approach the diagnosis from a multidisciplinary point of view. Periodontal exploration by probing is essential to determine the periodontal status and rule out the presence of endoperiodontal lesions of periodontal origin, as well as vertical fractures[3].

Conservative therapeutic options for failures of endodontic origin are non-surgical root canal retreatment and periapical surgery. Various studies show similar success rates (around 75%) for both treatments, so other aspects should be considered before deciding which to follow; such as ease of access via the coronal approach and the quality of the root canal obturation from previous endodontic treatments[4,5].

The intracanal posts in the single-root teeth in our case, whose removal would have entailed the sacrifice of the scarce remaining tooth that could remain under the metal ceramic crowns, made us opt for periapical surgery on these teeth. However, tooth 26 was underfilled by several millimetres in the buccal roots and the CBCT showed an omitted MP canal, so we opted for non-surgical root canal retreatment in this tooth.

Authors such as Kim et al. highlight the importance of some aspects of the current surgical technique with respect to traditional periapical surgery, such as the performance of 3 mm apicoectomies without bevel, apical retropreparations with ultrasound and retrograde obturation with bioceramic materials; all this using the operating microscope, which is the fundamental tool that has greatly improved the prognosis of these treatments[6].

When performing combined endodontic-surgical treatment, one of the decisions to make is whether or not combined techniques of guided bone regeneration (GBR) should be applied[7].

As in other maxillo-mandibular bone defect reconstructions, we must know if the defect has a critical or non-critical size[8,9]. In the former, spontaneous regeneration will not occur in the patient while, in the latter, bone regeneration of the defect can be expected if the appropriate conditions, including the following, are met[10]

- Maintenance of the volume of the defect to be regenerated.
- Having a stable clot within this volume, which allows for its organisation and the migration of bone-forming cells.
- Preventing the invasion of fibroblasts and soft tissue surrounding the area from regenerating.

Another factor to take into account to determine the possibilities of regeneration of the periapical bone defect is the number of walls destroyed by the infectious process. The same degree of spontaneous recovery cannot be expected from multiwalled bone defects[11], despite proper apical sealing and removal of associated inflammatory tissue.

In our case, we found different situations regarding periapical lesions, since they affected multiple teeth of different anatomies with different degrees of success in applying the aforementioned treatment.

In teeth 12, 11 and 25, the bone defect present was small (estimated at 0.2, 0.03 and 0.05 cm^3, respectively) with the absence of a wall. After the surgical approach, ostectomy with drilling bone in the apical area and curettage, it provided a favourable architecture for spontaneous regeneration; thus, the most reasonable attitude was not to provide biomaterials to try to improve bone regeneration.

However, the initial situation of piece 21, with a defect of 0.35 cm^3 with two opposing walls of full vestibular-palatal thickness, which reached the nasopalatine vasculo-nervous pedicle without a break in continuity, suggested a different strategy.

In this type of bone defect, the cavity or residual space left after curettage of the apical granuloma tends to collapse more easily than those present at the level of 12, 11 and 25, where there is no possibility of invasion of fibroblasts from the palatal slope.

Therefore, after performing the apicoectomy and apical sealing of the ducts with Biodentine™ (Septodont), we applied additional GBR techniques to maintain this volume using resorbable collagen membranes (Bio-Gide™, Geistlich) as a containment mechanism for the invasion of soft tissue on both the buccal and palatal slopes, associating the filling of the cavity with 0.5 g of porous bone matrix of bovine origin (Bio-Oss™, Geistlich) to prevent the collapse of the collagen membrane and to act as osteoconductive material[12].

Radiological checks were carried out at 6, 12 and 18 months using CBCT, which showed the absence of symptoms and a reversal of the chronic infection, as well as progressivity and stability in apical bone regeneration. At the level of 21, periapical radiopacity was observed, without loss of volume, and an absence of invasion of the space preserved by the surrounding soft tissue. Although some authors have used plasma rich in growth factors (PRGF) associated with Bio-Oss™ and Bio-Gide™ in cases similar to ours, we obtained adequate results without using PRGF as an additional technique[13].

The size of the rest of the periapical lesions led to favourable spontaneous regeneration, confirming that it is not necessary to perform GSR on small lesions that have no tunnel defect, as is the opinion of other authors[7,14].

CONCLUSIONS

1. Endodontic retreatment combined with periapical microsurgery are effective tools in the conservative treatment of periapical lesions of endodontic origin.
2. Multidisciplinary diagnosis is essential to determine the most appropriate treatment in each case.

CLINICAL RELEVANCE

Diagnostic and therapeutic advances in the field of endodontics and periapical surgery allow a conservative approach to endodontic lesions, so teeth can be maintained and the bone, lost as a result of the lesions, can be recovered.

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Systematic review

Use of particulate dentin in alveolar preservation procedures: a systematic review

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ABSTRACT

Introduction: The biological processes that take place following dental extractions cause defects in the soft and hard tissues of the jaw, which hinder rehabilitation techniques with implants. Alveolar preservation procedures have been proposed to decrease these dimensional changes. Although autogenous bone is considered the material with the best properties, it also leads to an increase in patient morbidity. Therefore, the tooth itself is considered as an alternative. The objectives of this review were to analyse the dimensional changes in alveolar ridge height/width after alveolar preservation procedures using particulate dentin, as well as possible intraoperative and postoperative complications, new bone formation and re-entry time in the grafted area.

Materials and method: A review of the relevant literature in the PubMed and MEDLINE databases was carried out, identifying studies evaluating alveolar preservation procedures with particulate dentin in human patients with recorded follow-up.

Results: A total of 12 studies were included in the systematic analysis. The dimensional changes, after grafting with particulate dentin, were comparable to those of other biomaterials and fewer than in the control groups. The occurrence of complications was low. New bone formation and re-entry time were similar to other biomaterials.

KEYWORDS

Particulate dentin; Demineralised dentin matrix; Extracted tooth; Alveolar preservation; Autogenous tooth; Bone graft; Regeneration.

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INTRODUCTION

Maxillary bones are delicate structures subject to reabsorption processes, which can cause defects and limit implantological rehabilitating techniques[1]. Dental extraction is one of the main reasons for these alterations in hard and soft tissue, as it can drastically modify alveolar crest volume[2]. Much research has been done to evaluate the effectiveness of various biomaterials in alveolar preservation procedures. Studies in animals[3] and humans[4] show minor volumetric changes, despite the techniques used to prevent them. Among the biomaterials used in alveolar preservation, autogenous bone is the most predictable due to its rapid revascularisation and resistance to infection[5]. However, this biomaterial also has disadvantages, such as limited availability, an increase in morbidity in the process of obtaining it and associated risks during surgery. Particulate dentin, however, is considered as an autogenous alternative with less morbidity. The results reported in the literature on this graft have been satisfactory, in vitro[6], in preclinical models in animals[5,7,8] and in clinical studies in humans[9,10]. The objective of this review was to look at existing evidence about alveolar preservation procedures with particulate dentin.

MATERIAL AND METHODS

Protocol

This review was carried out based on the PRISMA criteria (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). A protocol was designed following the PICO system to answer the following question: "In patients awaiting alveolar preservation after tooth extraction, how effective is particulate dentin compared to other grafts or control patients left to heal conventionally?"

(P) Population: Patients who need a tooth extraction

(I) Intervention: Alveolar preservation procedures with particulate dentin

(C) Comparison: Control patients or use of different biomaterials

(O) Outcomes: Dimensional changes in height/width (mm) of the alveolar crest after the therapy; analysis of intra and postoperative complications; new bone formation; and re-entry time.

Search strategy

The search was carried out in April 2020 according to the established inclusion and exclusion criteria, without restrictions for age, gender or race. Included studies were identified using the search terms "(particulate dentin) OR (demineralised dentin matrix) OR (extracted tooth AND ridge preservation) OR (autogenous tooth AND bone graft) OR (extracted tooth AND regeneration)" via PubMed at the MEDLINE database.

Inclusion and exclusion criteria

Inclusion criteria:

- Clinical trials, cross -sectional studies, cases series, case reports, cases control studies and cohort studies.
- Studies that include volumetric changes, complications and/or new bone formation in alveolar preservation procedures with particulate dentin.
- Studies that include patient monitoring.

Exclusion criteria:

- Duplicate studies.
- Studies with no design details.
- In vitro studies in animals, bibliographic reviews, systematic reviews and meta-analyses.
- Studies that included patients with compromised systemic health.
- Studies published in languages other than English or Spanish.

Data organisation

The data obtained from reading the complete manuscripts were collated and organised in two tables as follows:

Table 1: Author, study year, study design, number of patients, mean age/age range, number of alveoli, procedure and evaluation, monitoring, graft used, reason for extraction; and graft location.

Table 1. Study features.

Author	Year	Design	Patients	Mean age (range)	Alveoli number	Procedure and Evaluation	Follow-up	Graft	Reasons for extraction	Graft location
Gomes et al.[11]	2006	Controlled Clinical Trial	14	(15-40)	27	Alveolar preservation; Density analysis by periapical X-ray	3 months	No graft (control), PTFE or PTFE+ADM (particulate dentin)		3rd lower molars
Kim et al.[14]	2014	Case series	13	54	15	Alveolar preservation; Histological analysis; Periapical X-ray and orthopantomography	Max 24 months; Mean 22.5 months	Particulate and/or block dentin and/or membrane and/or allograft		Upper jaw: 2 molars. 2 premolars Lower: 10 molars, 1 premolar
Joshi et al.[21]	2016	Randomised controlled trial	15	35.6	45	Alveolar preservation. CBCT and histological analysis	4 months	Group 1 (control): without graft; Group 2: B-TCP; Group 3: ATG (particulate dentin)		Upper jaw: 18 Lower:12
Pang et al.[16]	2017	Randomised controlled trial	24	59.54	33	Alveolar preservation; Dimensional and histological analysis	6 months	AutoBT Group: Particulate Dentin; Xenograft Group: Bio-oss		Upper: 4 anterior, 3 premolar, 14 molar. Lower: 2 premolar, 10 molar
Valdec et al.[23]	2017	Case series	4	(36-65)	4	Alveolar preservation, CBCT and histological analysis	12 months	Particulate dentin + palate soft tissue graft	Necessary	
UM et al.[19]	2018	Case series	16	57	16	Alveolar preservation, CBCT and histological analysis	3-6 months	Control: DDM (particulate dentin) Test: DDM + rhBMP-2	Necessary	
Minamizato et al.[12]	2018	Cohort study	16	(25-73)	8	Alveolar preservation; Panoramic x-ray and histology	6 months	APDDM (particulate dentin)	Mesiodens, periodontitis, decay or fracture	3 molars, 2 premolars and 3 anterior
Cardaropoli et al.[25]	2019	Case report	1	35	1	Alveolar preservation and palate graft; Histological analysis and CBCT.	6 months	Particulate Dentin	Decay	Upper jaw: 2nd premolar
Del Canto-Díaz et al.[17]	2019	Clinical trial	6	47.6	12	Alveolar preservation, CBCT and density analysis	4 months	Control: No graft + collagen membrane. Test: ADM (particulate dentin) + collagen membrane	Impossible prognosis, decay or fractures	Single-rooted teeth
Pohl et al.[18]	2020	Clinical trial	13	51	61	Alveolar preservation, CBCT and histological analysis	Mean: 4 months	Particulate dentin + PRF/ collagen sponge	Impossible prognosis	Upper jaw: 19. Lower: 39. 22 incisors, 12 canines, 19 premolar and 5 molar
Andrade et al.[13]	2020	Clinical trial	4	54	10	Alveolar preservation and subsequent implantation. CBCT and biopsy.	4-6 months	Particulate dentin + LPRF + fibrinogen	Decay, endodontic pathology or periodontitis	Upper jaw: 4 incisors, 5 canines and 1 premolar.
Minetti et al.[15]	2020	Clinical trial	28	51.79	34	Alveolar preservation, Histological analysis	4 months	Particulate dentin and resorbable membrane	Trauma, decay or periodontal disease	6 incisors, 8 premolars and 20 molars
Total			**154**		**266**					

Table 2: Author, height dimension change, width dimension change, complications, new bone formation and re-entry time.

RESULTS

The information flow diagram is shown in Figure 1. The initial search identified a total of 4,095 articles. After applying the search criteria, 3,737 articles were

Table 2. Study results.

AUTHOR	Dimensional changes		Other results		
	Height	Width	Complications	New bone formation	Biocompatibility
Gomes et al.[11]	-		No	-	Yes
Kim et al.[14]	-	-	2 patients with dehiscence	-	Yes
Joshi et al.[21]	4 months: Control: -2.6 mm ATG: -0.28 mm	4 months: Control: -2.29 mm ATG: -0.15 mm	No	Yes	Yes
Pang et al.[16]	6 months: AutoBT: 5.38 mm Bio-oss: 6.56 mm	-	No	6 months: AutoBT: 31.24% Bio-oss: 35%	Yes
Valdec et al.[23]	1 year: -0.76 mm	1 year: -1.1 mm	No	Yes	Yes
UM et al.[19]	3-6 months: DDM: - 0.77mm (6.14%) DDM/rhBMP-2: -0.27 mm (2.51%)	3-6 months: DDM: - 0.67 mm (7.61%) DDM/rhBMP-2: -0.47 mm (5.95%)	No	3-6 months: DDM: 29.75% DDM/rhBMP-2: 34.39%	Yes
Minamizato et al.[12]	Preservation	Preservation	No	Yes	Yes
Cardaropoli et al.[25]	-	Postqx vs 24 weeks: -1.3 mm (crestal level) -0.9 mm (3 mm apical from crestal level)	No	Yes	Yes
Del Canto-Díaz et al.[17]	16 weeks: Control: -1.77 mm (16.87%) ADM: -0.42 mm (4.2%)	16 weeks: 1 mm crestal: Control: -1.91 mm (59.4%) ADM: -0.46 mm (14.9%) 3 mm crestal: Control: -1.3 mm (39.5%) ADM: -0.21 mm (6.66%) 5 mm crestal: Control: -0.89 mm (10.2%) ADM: -0.01 mm (0.3%)	No	-	-
Pohl et al.[18]	4 months: Bucal: +0.16 mm Lingual: +0.4 mm	4 months: 1 mm crestal: -1.38 mm 3 mm crestal: -0.82 mm 5 mm crestal: -0.43 mm	No	Yes	Yes
Andrade et al. [13]	-	-	No	4 months: 26.3% 5 months: 56.5% 6 months: 66.5%	Yes
Minetti et al.[15]	-	-	No	4 months: G1: 36.68% G2: 39.16 %	Yes

discarded. After reading titles and abstracts, 309 articles were excluded. The complete manuscripts of the remaining 49 articles were read and another 37 were excluded according to the inclusion and exclusion criteria. Finally, 12 articles were included in the review.

Table 1 contains information from the studies included in the review. Of the articles included (n=12), there were 6 clinical trials, 1 cohort study, 1 case report, 3 case series and 1 retrospective radiographic study. All articles were published between 2006 and 2020. The average age of the patients was between 35 and 59 years, except for 2 studies[11,12] that reported ranges between 15 and 73 years. The total number of patients included in the publications selected was 154, which was an average of 12.83 patients per study. The number of alveoli studied was 266, an average of 1.7 per patient. The samples were balanced regarding participant sex.

All studies evaluated the effectiven ess of particulate dentin in alveolar preservation. Some studies also evaluated other regenerative or rehabilitative procedures. Follow-up was between 3 and 24 months. The graft material used was particulate dentin in all studies, combined in some studies with other filler or membrane biomaterials.

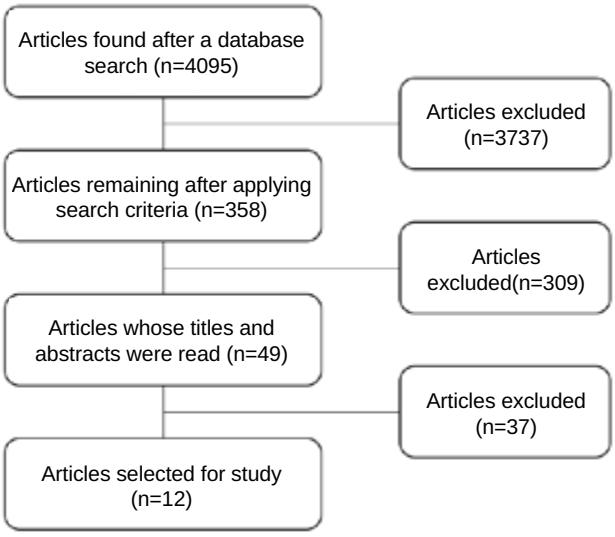

Figure 1. Information flow diagram.

Dimensional changes

The dimensional change results are found in Table 2. Except for 4 studies[11,13-15], most evaluated the dimensional changes in height and/or width. They were calculated as the difference between the beginning and end of the procedure, except for Pang et al[16], who analysed the vertical gain from the end of the defect to a resin model placed on adjacent teeth. Minamizato et al.[12] assessed alveolar preservation, but did not quantify it.

Complications

The results for complications are in Table 2. All studies reported an absence of complications in alveolar preservation procedures with particulate dentin, except for one[4], in which two patients developed dehiscence during healing; a second attempt provided proper healing.

New bone formation

The new bone formation results are in Table 2. This was recorded in all but 3 studies[11,14,17]. All these studies found new bone formation, with the range varying from 26.3% to 66.5%, depending on the study.

Re-entry time

Re-entry time results are in Table 2. This was recorded in all but 3 studies[11,17,18], with the rest of the studies recording re-entry time for the insertion of implants and/or taking a biopsy. This period varied between 3 and 6 months.

DISCUSSION

At present, scientific evidence on the use of particulate dentin in alveolar preservation procedures is limited. Few published studies were identified, and these were of low sample size and short-term follow -up. However, this biomaterial is considered a promising alternative. The purpose of this review was to gather the data reported in the literature evaluating four aspects: (a) vertical and horizontal dimensional changes; (b)

intra and postoperative complications; (c) new bone formation; and (d) re-entry time in the grafted area.

Dimensional changes

Vertical:

At 3 and 6 months of the Alveolar preservation, Um et al.[19] recorded losses of -0.77 mm (6.14%) in the particulate dentin group. These are similar to losses reported at 6 months by Pelegrine et al.[20], who performed alveolar preservation with an autogenous bone graft (0.62 mm).

At 4 months, Joshi et al.[21] and Del Canto-Díaz et al.[17] analysed losses of -0.28mm and -0.42mm, respectively, in the particulate dentin group. In this same period, Matchei et al.[22] reported losses of -0.25 mm in patients grafted with bovine xenograft. These losses were greater at -1.71 mm in the control group of this same study, which left the socket to heal spontaneously.

At 12 months, Valdec et al.[23] recorded a loss of -0.76 mm in the particulate dentin group, although at this time the implants had already been placed. However, these results are similar to other studies in the literature, such as Barone et al.[24], who recorded -0.7 mm after the use of xenograft. Buccal losses were 3.6 mm in the control group of this last study.

Horizontal:

After 3 months, Um et al.[19] recorded decreases of -0.67 mm in the particulate dentin group, while, Joshi et al.[21] recorded -0.15 mm at 4 months. These are an improvement when compared with those published in the classic Schropp et al. study[2], where dimensional changes were analysed after extraction without a graft, where losses were -3.8 mm at 3 months.

Pohl et al.[18] and Del Canto-Díaz et al.[17] measured these horizontal changes in procedures with particulate dentin at 4 months, 1 mm apical to the base of the bone crest and 3 mm apical to the base of the bone crest. Respectively, they reported losses of -1.38 mm and -0.46 mm at 1 mm from the crest, -0.82 mm and -0.31 mm at 3 mm from the crest, and -0.43 mm and -0.01 mm at 5 mm from the crest. Following this form of measurement in different planes of the crest, Cardaropoli et al.[25] studied losses at the crest level (-1.3 mm) and at 3 mm from the crest (-0.9 mm) at 6 months after procedures with particulate dentin.

All these results are better than other studies detailed below, where xenograft or control groups were used and the measurements were also recorded at different points of the crest vertically. Matchei et al.[22] reported decreases of -1.56 mm at 3 mm from the crest in the xenograft group at 4 months. In the control group of this same study, the losses were -2.96 mm at 6 mm from the crest, with larger losses (-0.56 mm in the xenograft group, and -1.81 mm in the control group), when compared with the particulate dentin groups. After 1 year, Valdec et al.[23] reported losses of 1.1 mm in grafted alveoli with particulate dentin, rehabilitated with implants, which was much less than another study[2] without grafts, which were as high as 50%.

Complications

Only one study[14] reported complications after the alveolar preservation procedure with particulate dentin. These results are similar in studies which used a xenograft as biomaterial[26, 27]. This suggests high predictability and safety in treatment with particulate dentin.

New bone formation

The Andrade et al. study[13] reported new bone formation of 26.3% at 4 months for the particulate dentin group, while Minetti et al.[15] reported a range between 36.68% and 39.16%. These results exceed those obtained with allograft at 4 months, where the formation observed by Spinato's 2014 study[28] was between 18.84% and 23.3%. The results of the xenograft groups were also in this range at 4 months for the Matchei et al. study[22] which reported 22.50%.

At 5 months, Andrade et al.[13] reported up to 56.5% of new bone in particulate dentin groups, while Um et

al.[19] found 29.75% between 3 and 6 months. Particulate dentin gave higher percentages when compared with xenograft treated groups[29].

At 6 months, the dentin results[13,16] (31.24% and 66.5%, respectively) were similar to other studies where the groups were treated with autogenous bone (45.47%)[20] or xenograft (25.7%)[24].

Re-entry time

Re-entry was performed between 3 and 6 months in all studies. This waiting time is similar to studies with autologous graft[20], xenograft[22-29] and allgraft[28]; and lower than in other xenograft studies[24]. This leads us to think that the use of autogenous tooth has some properties at least as good as other widely used biomaterials. These results agree with the findings of the systematic review by De Risi et al.[30] which concluded that alveoli grafted in alveolar preservation processes do not require a longer re-entry period than those healing spontaneously.

CONCLUSIONS

Current scientific evidence on the use of particulate dentin in alveolar preservation procedures is limited.

Of the few published studies identified, their sample size was low and the follow-up was short-term. Therefore, more and better studies are necessary.

Given the limitations of this bibliographic search, we can conclude that the use of particulate dentin is an alternative to other widely used biomaterials, with clear advantages over the lack of preservation procedures.

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Clinical utility properties of new endodontic silicate-based sealers: a systematic review

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ABSTRACT

Introduction: Filling in the root canal system plays a key role in the success of endodontic treatment. New silicate-based sealers have recently been introduced on the market to improve the properties of sealers used in these treatments. Before performing endodontic treatment, it is always useful to know the properties of different sealers.

Objectives: The aim of this study was to review the literature and compare the clinically useful properties of new silicate-based sealers with those of conventional epoxy resin-based cements.

Methods: After establishing the adapted research question, a literature review was carried out in two databases (Medline via Pubmed and Wiley Library via Cochrane Library) combining MeSH (Medical Subject Headings) and free terms. A manual electronic search was also performed. The clinically useful properties selected were discolouration, sealing capacity, radiopacity, setting time and solubility.

Results: Of the 224 potential studies obtained, 20 were selected for reading of the full text. Another 4 studies were selected after manual electronic searching of which 2 were excluded, leaving 22 studies for inclusion in the review. The following physical properties were analysed: 2 for tooth discolouration; 4 for sealing ability; 11 for radiopacity; 9 for setting time; and 12 for solubility; 9 of the articles evaluated several properties.

Conclusions: No differences in tooth discolouration were observed between silicate-based and resin sealers. No differences in sealing ability were observed in most of the studies consulted. All sealers analysed showed radiopacity values within the recommended standards. Both setting time and solubility depended on the type of sealer; with some of the silicate-based sealers having higher solubility than the resin-based.

KEYWORDS
Sealing; Endodontic sealers; Bioceramic sealers; Resin sealers.

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INTRODUCTION

After shaping and cleaning the route canal system, complete sealing is needed for success in endodontic treatment[1]. The materials used regularly for sealing are gutta-percha and sealing cements[2]. Sealing cements are substances capable of penetrating between the sealer material and root canals[3]. There are different types on the market, however, despite having many of the properties described by Grossman, they do not have them all[4]. They can be classified according to their main components[5]: Zinc oxide eugenol, calcium hydroxide, glass ionomer, silicone, resin and bioceramic cements[6].

Currently, those composed of resins are used most, with the epoxy resin cement AH Plus™, being considered the Gold Standard[3,7]. However, this cement has a series of limitations, which are possible cytotoxicity, mutagenicity and inflammatory response[8]. Another limitation is its lack of bioactive properties[9]. Therefore, new types of sealant called bioceramic cements[10] have recently arrived on the market. These cements are based on the biological properties of MTA[11] and include calcium silicates, phosphates and hydroxide as well as zirconium oxide as a radiopacifier[12]. The development of bioceramic cements has been based on obtaining good biocompatibility; however, these cements must also have adequate physical properties[4].

One of the issues that has gained importance in recent years is aesthetics[7]. The aesthetic result of root canal treatment is important, especially in the anterior region[13], as some remains of sealant cement can be left behind, despite the access cavity being adequately prepared and cleaned with alcohol[14]. Sealing capacity is another property of new sealant cements considered important[5]. The dimensional changes of the root canal system, and the lack of adhesion of gutta-percha, make a complete seal necessary to obtain. Thus, adaptation of the sealant cement is a factor that influences the microfiltration and reinfection of the root canal system[15]. Another property considered essential is radiopacity, as it means clinicians can distinguish between the materials used and adjacent anatomical structures[16], as well as evaluate the quality of the root canal filling[17].

Another physical property the clinician must take into account is setting time. Slow or incomplete setting can lead to greater tissue irritation[18], while too short a setting time can reduce working time by complicating and interfering with the sealing process[19]. Therefore, the setting time must be long enough to allow easy handling, especially for sealing techniques that require more time[20]. Solubility is another property that has special relevance when evaluating sealant cements[21]. Dissolution of the sealant cement can interfere with the quality of the root canal treatment and trigger an inflammatory response of the periapical tissues[21,22]. There may also be a vacuum between the sealer material and the root canal, increasing infiltration over time[21]. Therefore, sealant cements have low solubility[22].

It is important to know the physical properties of the different resin based cements on the market. The objective of this systematic review was to analyse the scientific evidence behind the different properties of clinical significance of silicate-based sealants - such as dental discoloration, sealing capacity, radiopacity, setting time and solubility - and compare them with conventional resin cements.

MATERIAL AND METHODS

Considering the non-clinical nature of studies in the bibliography, the following PICO research question was applied to carry out this review: *Do silicate-based cements have better properties of discolouration, sealing, radiopacity and solubility compared with conventional epoxy resin-based cements in teeth or samples?* (see Figure).

The bibliographic search was carried out in the Medline databases via Pubmed and the Wiley Online Library via the Cochrane Library. MeSH terms (Medical Subject Headings) were combined with free terms, in single or multiple combinations using Boolean operators. In vitro studies published between 2015 and 2021 were included. The last search was performed on January 31, 2021. Studies that evaluated cements that were not marketed or with changes in the composition of

marketed cements were excluded. Studies comparing changes in physical properties or sealing techniques were also excluded. The search equations used applied in the English language are described in Table 1. In addition, a manual electronic search was carried out in the Journal of Endodontics, International Journal of Endodontics, Australian Endodontic Journal and Iranian Endodontic Journal.

A preliminary selection of the articles made by title and abstract was then done. Duplicate articles were discarded. Full-text articles were then obtained, excluding articles that did not meet the established criteria. Manually selected articles were added and those that did not meet the established criteria were excluded. The selected articles were grouped according to the property analysed. Those articles that analysed more than one property were identified and included in the corresponding groups. Taking into account the nature of the review, the properties of the studies were summarised descriptively.

RESULTS

The article selection flowchart is seen in the Figure. The initial search provided 224 studies with no duplicate articles found. After evaluating the study titles and abstracts in the initial search, 204 studies were excluded as they did not meet the inclusion criteria, leaving 20 studies for reading of the full text. To these were added 4 studies obtained via a manual electronic search. After reviewing the full text of the 24 studies, 2 were excluded for not including a comparative epoxy resin group[23,24]. Therefore, the final number of articles included in the literature review for data extraction was 22. These studies were grouped according to the property analysed (Table 2): 2 discolouration (A); 4 sealing capacity (B); 11 radiopacity (C); 9 setting time (D); and 12 solubility (E). 9 articles analysed various properties.

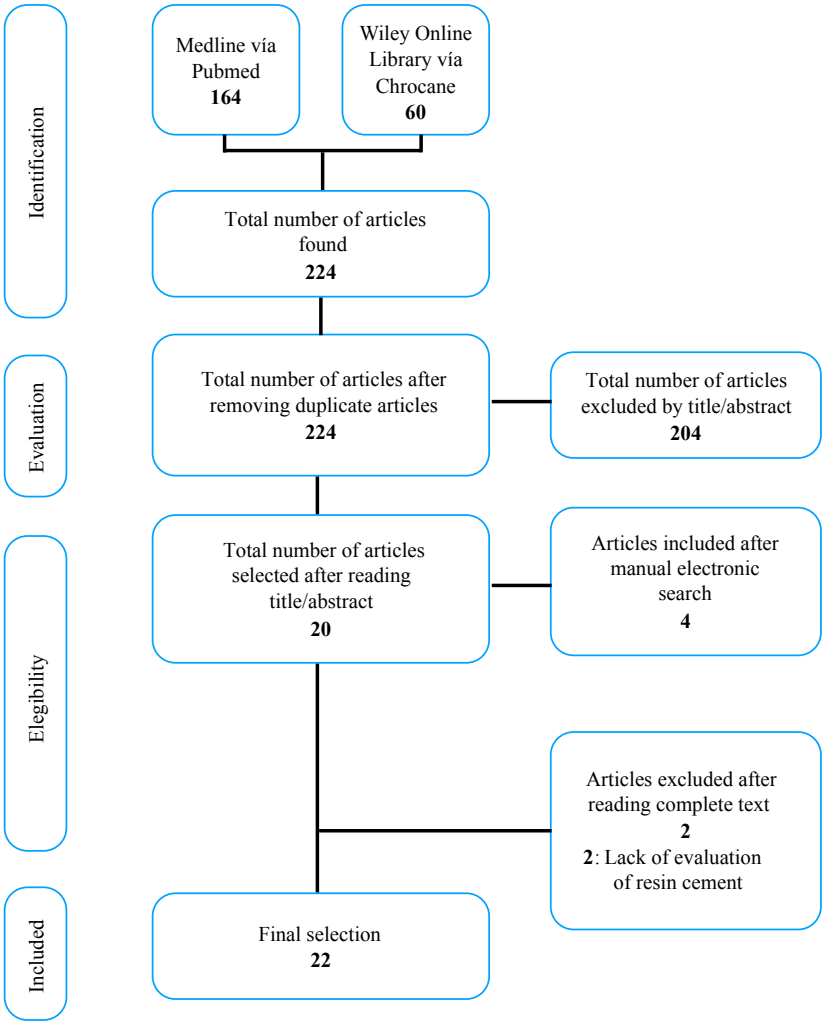

Figure. Flow diagram of study selection process.

DISCUSSION

The selected articles evaluated different physical properties of the new silicate-based endodontic sealant cements. Standardised methodologies had to be established to evaluate the different cement properties so the results could be reproduced and reliable comparisons of the data made[19].

Discolouration of dental tissue

The studies that looked at discoloration evaluated the same resin-based cement, AH Plus™[7,14]. However, they evaluated different silicate-based cements, including Endo-Seal™[14], MTA Fillapex™ and iRoot™ SP[7]. They evaluated the discolouration of 100 teeth between both studies, using both bovine[14] and human[7] teeth. Both studies used CIE-Lab system spectrophotometry to evaluate the discolouration, applying different evaluation periods: 0-2 months[14] and 0-6 months[7].

The results obtained in the two studies showed no significant differences in discolouration between the cements analysed and the AH Plus™ resin-based cement. However, Forghani et al.[7] observed a progressive discolouration of all cements during the first 3 months after placement, with a tendency to decrease during the second trimester and up to the 6th month of evaluation.

Sealing capacity

There were 4 studies that evaluated the sealing of the new silicate-based cements[5,15,25,26]. One study evaluated BioRoot™ RCS[5], two analysed Endosequence™ BC Sealer[15,25] and one studied iRoot™ SP[26]. All studies compared with AH Plus™ resin cement.

No differences were found in the sealing capacity between silicate-based and epoxy resin-based cements in 3 of the studies[5,15,26]. However, Endosequence™ BC Sealer silicate-based cement was considered better than epoxy resin cement in one of the studies[25].

Radiopacity

There were 11 silicate-based cement studies[9,16,17,19,20,27-32] that compared the radiopacity with epoxy resin-based cements. The silicate-based cements analysed were: EndoSequence™ BC Sealer[16], EndoSeal™ MTA[16,28], TotalFill™ BC Sealer[9,30], BioRoot™ RCS[20,29,31], MTA Fillapex™[16,20,31,32], Sealer Plus™ BC[17,19,27] and BioC™ Sealer[9]. All studies evaluated AH Plus™ epoxy resin-based cement. In addition, 2 studies also evaluated the epoxy resin-based cements ADSEAL™, Radic-Sealer™[16] and Sealer Plus™[32].

The American National Institute of Standards and the American Dental Association (ADA) establish a minimum radiopacity of 3.00 mm Al in their specification number 57 for the year 2000[33]. The standard established by the International Organisation for Standardisation (ISO) 6878 also specifies a radiopacity greater than or equal to or 3 mm Al[31]. All cements evaluated had radiopacity values within the recommended ISO standards.

In most studies, AH Plus™ cement had higher radiopacity values than the silicate-based cements BioRoot™ RCS[29,31], TotalFill™ BC[9,30], Bio-C™ Sealer[9], Endosequence™ BC Sealer[16], Sealer Plus™ BC[17,19,27], MTA Fillapex™[9,30,32] and Endoseal™[28]. However, other studies found no significant differences between AH Plus™ and BioRoot™ RC, MTA Fi- llapex™[20] and EndoSeal™ MTA[16]. In studies that also analysed other resin-based cements, the silica-based cements radiopacity results were similar. The MTA Fillapex™ had lower radiopacity than Sealer Plus™[9], Pulp Canal Sealer™[31], Radic-Sealer™ y AD Seal™[16] resin cements.

Similarly, the BioRoot™ RCS cement had a lower radiopacity than the Pulp Canal Sealer™[31]. Meanwhile, the Endosequence™ BC Sealer cement also had a lower

Table 1. Search equations.

Database	Evaluation
Medline (via Pubmed)	((Tooth [Mesh] OR specimen) AND/OR ("Epoxy Resins"[Mesh] OR tricalcium silicate endodontic sealer OR calcium-silicate based sealer) AND ("tooth discolouration"[Mesh] OR discolouration OR sealing OR radiopacity OR setting time OR solubility))
Cochrane	(MeSH descriptor: [Tooth] AND/OR MeSH descriptor: [Root Canal Filling Materials])

radiopacity than the Radic Sealer™. However, the Endosequence™ BC Sealer had a greater radiopacity than the AD Seal™[16].

When evaluating differences in the radiopacity of silicate-based cements, the results between studies differ depending on the cements analysed. One study observed greater radiopacity with MTA Fillapex™ than with BioRoot™ RCS[31]. However, no difference was found between either cement in another study[20], nor between Bio-C™ Sealer and TotalFill™ BC Sealer[9]. The only study that analysed 3 silicate-based cements[16] had different radiopacity values for the cements, with EndoSeal™ MTA being the highest, followed by Endosequence™ BC Sealer then MTA Fillapex™. The differences in radiopacity could be caused by the presence of different radiopacifying agents in the composition of the cements[16].

Setting time

The 9 selected studies[9,17-20,27,29,30,32] evaluated the setting time using needles inserted into the cement models, as established by the IS0 6876[19] ANSI/ADA 57[27] standard.

The following silicate-based cements were evaluated: BioRoot™ RCS[20,29]; Sealer Plus™[17,18,27]; TotalFill™ BC Sealer, Bio-C™ Sealer[9,18,30] and MTA Fillapex™[20,32]. In all studies, the setting time results of the silicate-based cements were compared with AH Plus™ epoxy resin cement. One study also analysed Sealer Plus™[32].

Two studies analysed the setting time of BioRoot™ RCS[20,29]. Both found that BioRoot™ RCS had a lower setting time than the resin-based cement AH Plus™[20,29]. In one of the two studies[20], they also evaluated the setting time of MTA Fillapex™ cement, which was completed after 1 week, the evaluation period established in the study. In another study, MTA Fillapex™ had a longer setting time than AH Plus™ and Sealer Plus™ cements™[32].

Three studies evaluated Sealer Plus™ BC[17,19,27] silicon-based cement. As with the results observed with BioRoot™ RCS cement, Sealer Plus™ BC also had a lower setting time than AH Plus™ epoxy resin cement[17,19,27]. Two studies[18,30] analysed TotalFill™ BC Sealer. In both, the setting time of the silicate-based cement was lower than that of AH Plus™. However, the two studies that analysed Bio-C™ Sealer cement differed in their results. One study had the AH Plus™ cement with a shorter working time than Bio-C™ Sealer[9], while the other study[18] had AH Plus™ epoxy resin-based cement with a longer setting time than Bio-C™ Sealer.

When analysing the setting time of silicate-based cements, one study[20] found no differences between BioRoot™ RCS and MTA Fillapex™ cements, while two studies found a shorter setting time for Bio-C™ Sealer with respect to the TotalFill™ BC Sealer[9,18]. In one of the studies[18], this cement did not set after the 25 days established under the study conditions.

Solubility

There were 12 articles that compared the solubility of sealant cements with epoxy resin cements[5,9,17,19,20,27,28,30,34-37]

The selected studies analysed silicate-based cements: BioRoot™ RCS[20,34,37]; MTA Fillapex™[20,32,34-37]; TotalFill™ BC Sealer[9,30,34]; Sealer Plus™ BC[17,19,27,33]; Bio-C™ Sealer[9] and Endoseal™[28]. All studies used AH Plus™ resin cement as the control group. Two articles analysed the properties of Obturys™[34] and Sealer Plus™[32]. Differences were observed between the different silicate-based cements and the evaluation periods, in relation to the resin-based cements. The BioRoot™ RCS cement had greater solubility than the AH Plus™[20,34,37] and Obturys™[34]. The Bio-C™ Sealer also had greater solubility than the AH Plus™[9]. Similarly, the TotalFill™ BC Sealer cement obtained greater solubility than the AH Plus™ resin cement in most of the periods analysed in the different studies[9,30,34]. However, in the first evaluation period of one study[34], no significant differences were observed between BioRoot™ RCS and the resin-based cements AH Plus™ and Obturys™. In most of the studies and periods analysed for MTA Fillapex™ cement, greater solubility was found compared to

Table 2. Review articles evaluating the sealant cement properties, (A) discolouration, (B) sealing, (C) radiopacity, (D) setting time and (E) solubility, according to the methodology described.

(A). Discolouration

Author/year	Evaluation	Silicate-based sealing cement	Resin-based sealing cement
Forghani et al.[7] (2016)	Discolouration	MTA Fillapex™ iRoot™ SP	AH Plus™
Lee et al.[14] (2016)	Discolouration	EndoSeal™ MTA	AH Plus™

(B). Sealing

Author/year	Evaluation	Silicate-based sealing cement	Resin-based sealing cement
Viapiana et al.[5] (2016)	Sealing	BioRoot RCS™	AH Plus™
Zhang et al.[26] (2017)	Sealing	iRoot™ SP	AH Plus™
Huang et al.[15] (2018)	Sealing	Endosequence™ BC Sealer	AH Plus™
Asawaworarit et al.[26] (2020)	Sealing	Endosequence™ BC Sealer	AH Plus™

(C). (C) Radiopacity

Author/year	Evaluation	Silicate-based sealing cement	Resin-based sealing cement
Lim et al.[27] (2015)	Radiopacity	EndoSeal™	AH Plus™
Khalil y cois.[29] (2016)	Radiopacity	BioRoot™ RCS	AH Plus™
Prüllage et al.[20] (2016)	Radiopacity	BioRoot RCS™, MTA Fillapex™	AH Plus™
Tanomaru-Filho et al.[28] (2017)	Radiopacity	TotalFill™ BC Sealer™	AH Plus™
Lee et al.[16] (2017)	Radiopacity	EndoSeal™ MTA, MTA Fillapex™, Endosequence™ BC Sealer	AH Plus™ ADSEAL™ Radic-Sealer™
Siboni et al.[30] (2017)	Radiopacity	BioRoot™ RCS, MTA Fillapex™	AH Plus™ Pulp Canal Sealer™
Mendes et al.[19] (2018)	Radiopacity	Sealer Plus™ BC	AH Plus™
Vertuan et al.[17] (2018)	Radiopacity	Sealer Plus™ BC	AH Plus™
Zordan-Bronzel et al.[9] (2019)	Radiopacity	Bio-C™ Sealer, TotalFill™ BC Sealer	AH Plus™
Tanomaru-Filho et al.[31] (2019)	Radiopacity	MTA Fillapex™	AH Plus™ Sealer Plus™
Silva et al.[32] (2020)	Radiopacity	Sealer Plus™ BC	AH Plus™

(D). etting time

Author/year	Evaluation	Silicate-based sealing cement	Resin-based sealing cement
Khalil et al.[29] (2016)	Setting time	BioRoot™ RCS	AH Plus™
Prüllage et al.[20] (2016)	Setting time	BioRoot™ RCS, MTA Fillapex™	AH Plus™
Tanomaru-Filho et al.[28] (2017)	Setting time	TotalFill™ BC Sealer	AH plus™
Vertuan et al.[17] (2018)	Setting time	Sealer Plus™ BC	AH Plus™
Mendes et al.[19] (2018)	Setting time	Sealer Plus™ BC	AH Plus™
Tanomaru-Filho et al.[31] (2019)	Setting time	MTA Fillapex™	AH Plus™ Sealer Plus™
Zordan-Bronzel et al.[9] (2019)	Setting time	Bio-C™ Sealer, TotalFill™ BC Sealer	AH Plus™
Silva et al.[18] (2020)	Setting time	Bio-C™ Sealer, TotalFill™ BC Sealer	AH Plus™
Silva et al.[32] (2020)	Setting time	Sealer Plus™ BC	AH Plus™

(E). Solubility

Author/year	Evaluation	Silicate-based sealing cement	Resin-based sealing cement
Lim et al.[27] (2015)	Solubility	Endoseal™	AH Plus™
Prüllage et al.[20] (2016)	Solubility	BioRoot™ RCS MTA Fillapex™	AH Plus™
Silva Almeida et al.[23] (2017)	Solubility	MTA Fillapex™	AH Plus™
Tanomaru-Filho et al.[28] (2017)	Solubility	TotalFill™ BC Sealer	AH Plus™
Mendes et al.[19] (2018)	Solubility	Sealer Plus™ BC	AH Plus™
Urban et al.[36] (2018)	Solubility	BioRoot™ RCS MTA Fillapex™	AH Plus™
Vertuan et al.[17] (2018)	Solubility	Sealer Plus™ BC	AH Plus™
Torres et al.[35] (2019)	Solubility	MTA Fillapex™	AH Plus™
Elayssy et al.[34] (2019)	Solubility	MTA Fillapex™ BioRoot™ RCS TotalFill™ BC Sealer	AH Plus™ Obturys™
Zordan-Bronzel et al.[9] (2019)	Solubility	Bio-C™ Sealer, TotalFill™ BC Sealer	AH Plus™
Tanomaru-Filho et al.[31] (2019)	Solubility	TotalFill™ BC Sealer	AH Plus™
Silva et al.[32] (2020)	Solubility	Sealer Plusv BC	AH Plus™

resin cements[20,32,34,35,37]. However, one study observed greater solubility for MTA Fillapex™ compared to AH Plus™ at 2 hours of evaluation[20]. Different studies found no solubility differences between both cements in the first minute of evaluation[20], at 24 hours[34] and after a week[34,36]. However, studies that analysed longer evaluation periods found the solubility of the MTA Fillapex™ cement was superior to that of the resin cement[32,35,37]. Meanwhile, the silicate-based Sealer Plus™ BC obtained contradictory results: in one study[19] it had greater solubility than AH Plus™, but no differences were found in 2 studies[17,27]. Similarly, the only study that analysed Endoseal™[28] found no differences in solubility with respect to AH Plus™ resin cement in the period analysed.

When evaluating the solubility between the different silicate-based cements, different results were observed between the different evaluation periods. The Bio-C™ Sealer cement had greater solubility than the TotalFill™ BC Sealer[9]. In one study, no significant differences were observed in the different periods between TotalFill™ BC Sealer, MTA Fillapex™ and BioRoot™ RCS cements, except for the first evaluation period (24 hours), in which BioRoot™ RCS cement had greater solubility than MTA Fillapex™[34]. However, the solubility of both cements differs between studies, as can be observed from the greater solubility of MTA Fillapex™ with respect to BioRoot™ RCS[20], as well as the greater solubility of BioRoot™ RCS cement in relation to MTA Fillapex™[37]. More research would be necessary to analyse the long-term solubility of both cements.

CONCLUSIONS

Taking into account the lack of long-term clinical studies and the limitations of in vitro studies, the physical properties of new silicate-based sealing cements can guide the dentist when carrying out the selection of sealing cement.

No differences in tooth discolouration between silicate-based and epoxy resin-based cements were observed. Neither were differences observed in sealing between both types for most of the studies selected. Both epoxy resin-based cements and silicate-based cements had radiopacity values within recommended ISO standards. The setting time of silicate-based cements in comparison with resin cements varied as a function of cement type. Although solubility varied as a function of cement type and evaluation period, some of the silicate-based cements showed higher solubility than resin-based cements.

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